

LABORATORY TESTING OF SNOWMOBILE EMISSIONS

Prepared by

**Chad C. Lela
Jeff J. White**

FINAL REPORT

Prepared for

**YELLOWSTONE NATIONAL PARK
National Park Service
P.O. Box 168
Yellowstone National Park, WY 82190**

and

**Howard Haines
Montana Department of Environmental Quality
1520 East Sixth Ave. (PPB)
Helena, MT 59620-0901**

July 2002

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AUTOMOTIVE PRODUCTS AND EMISSIONS RESEARCH DIVISION**

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ABBREVIATIONS AND GLOSSARY

C	Celsius
CARB	California Air Resources Board
cc	Cubic centimeters
CDI	Capacitive discharge ignition
CFR	Code of Federal Regulations
CO	Carbon monoxide
CO ₂	Carbon dioxide
CRC	Coordinating Research Council
CSC	Clean Snowmobile Challenge
cSt	Centistoke
CVS	Constant volume sampler
CVT	Continuously-variable transmission
°	Degree
DEQ	Montana Department of Environmental Quality
DNPH	Dinitrophenylhydrazine
ECM	Engine control module
EEE	EEE-Clear EPA Certification-grade gasoline (reference gasoline)
EFI	Electronic fuel injection
EGO	Exhaust gas oxygen sensor
EPA	Environmental Protection Agency
E10	10% ethanol and 90% gasoline fuel blend
E85	85% ethanol and 15% gasoline fuel blend
F	Fahrenheit
FEAT	Fuel Efficiency Automobile Test
5m	5-mode ISMA/SwRI engine dynamometer test cycle
4m	4-mode chassis dynamometer test cycle
4s	Four-stroke
g	Grams
GC	Gas chromatograph
g/gal	Grams per gallon
g/hp-hr	Grams per horsepower hour
g/hr	Grams per hour
HC	Hydrocarbons
HFID	Heated flame ionization detector
hp	Horsepower
HPLC	High performance liquid chromatograph
IBP	Initial boiling point
in.	Inches
ISMA	International Snowmobile Manufacturers Association
lb-ft	Pounds-feet
L/min	Liters per minute
M	Mass emission rates in grams per hour
mi	Miles
mL	Milliliters

ABBREVIATIONS AND GLOSSARY (CONTINUED)

mm	Millimeters
MON	Motor Octane Number
mph	Miles per hour
NDIR	Non-dispersive infrared analyzer
NO _x	Oxides of nitrogen
PM	Particulate matter
ppbC	Parts per billion
ppm	Parts per million
psi	Pounds per square inch
RON	Research Octane Number
RPM	Revolutions per minute
RVP	Reid Vapor Pressure
SAE	Society of Automotive Engineers
scfm	Standard cubic feet per minute
SORE	Small off-road engines
μL	Microliters
UV	Ultraviolet
V	Snowmobile track velocity in mph
VS	Five individual vehicle speeds that snowmobiles were tested
WOT	Wide-open throttle
YNP	Yellowstone National Park

EXECUTIVE SUMMARY

Snowmobile engine emissions are of concern in environmentally-sensitive areas, such as Yellowstone National Park. A program was undertaken to measure emissions from commercially-available four-stroke snowmobiles, as well as student-designed snowmobiles, and to compare their emissions to two-stroke sleds. Test vehicles included a 2002 Arctic Cat 4-Stroke Touring snowmobile, a 2002 Polaris Frontier 4-stroke engine, and two 4-stroke snowmobiles that competed in the 2002 SAE Clean Snowmobile Challenge. Fuels used were a reference gasoline and E10/gasohol (10 percent ethanol). For comparison, one of the student-designed snowmobiles was also tested on E85 (85 percent ethanol) to examine potential emission benefits with this fuel.

Emissions were measured using three different test protocols including the five-mode ISMA/SwRI snowmobile engine dynamometer test cycle, a four-mode chassis dynamometer cycle, and at snowmobile speeds of 15, 25, 35, and 45 mph, as well as top speed on the chassis dynamometer. Emissions measured included hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), carbon dioxide (CO₂), and particulate matter (PM). Selected Arctic Cat engine tests also determined individual hydrocarbon species (C₁-C₁₂), including ketones, aldehydes, and alcohols.

The following observations were made:

- Commercially-available 4-stroke snowmobiles are significantly cleaner than 2-stroke sleds. Compared to previously tested 2-strokes, these 4-stroke sleds emit 98-95 percent less HC, 85 percent less CO, and 90-96 percent less PM.

Four-stroke snowmobile NO_x, however, is considerably higher than from a 2-stroke, being increased by a factor of seven to twelve.

- The commercially-available 4-stroke snowmobiles emit roughly 90 percent less toxic hydrocarbons, such as 1,3-butadiene, benzene, formaldehyde, and acetaldehyde, than 2-stroke sleds.
- Four-stroke snowmobiles achieve approximately 40 percent better fuel economy than 2-stroke sleds.
- Use of a catalyst can further reduce snowmobile emissions. The University of Idaho CSC 2002 sled, that incorporates a 4-stroke, closed-loop controlled engine with catalyst, generated the lowest emissions of all sleds tested. Compared to the 4-stroke Arctic Cat sled, the Idaho sled emitted 64 percent less HC, 29 percent less CO, 99 percent less NO_x, and 36 percent less PM.
- Operation on E10 generally produced lower HC and CO emissions, but higher NO_x emissions, compared to reference gasoline.

- A snowcoach emission factor was estimated in a separate project for the State of Wyoming, based on laboratory chassis dynamometer measurement of emissions from a V-10 powered Ford E-350 15 passenger van. We were not able to exactly simulate conditions on the dynamometer equivalent to those seen in the field. At normal loads, the van's engine operates at stoichiometric, achieving very low emission levels. Running in snow on tracks generates tremendously higher engine loads than on-highway operation. A simulation of this on the chassis dynamometer provided a second emission value (open loop, rich), which may be more typical of real snowcoach operation.

	Emissions, g/mi		
	HC	CO	NO _x
Ford van, closed-loop, stoichiometric	0.044	0.76	0.54
Ford van, open-loop, rich	1.63	99.2	1.82
Arctic Cat 4-stroke snowmobile	2.3-3.3	20-140	2.4-6.5

Ford van emissions are based on a simulated snowcoach driving cycle, while Arctic Cat data are from steady-state operation on a chassis dynamometer. If one assumes that the open-loop Ford van emission value is close to real in-field operation, the snowcoach would appear to be the cleaner solution, given its ability to handle more passengers than a snowmobile. However, it should also be kept in mind:

- the estimated Ford van emission factor may be way off (it could be low)
- there are other types of snowcoaches in service that do not have the extremely clean Ford engine/catalyst package. Their emissions could be higher than the Ford's by an order of magnitude or more.
- as demonstrated by the Idaho sled, further significant reductions in snowmobile emissions could be achieved through the use of catalyst.

It is entirely possible that acceptable, low-emissions solutions can be developed for both snowcoaches and snowmobiles. This is one of the accomplishments of Lori Fussell and Bill Paddleford's SAE Clean Snowmobile Challenge.

I. INTRODUCTION

As snowmobile operation has increased in environmentally sensitive-areas, emissions data are needed to determine the potential impacts of operation. The majority of snowmobiles currently in operation use two-stroke spark-ignited engines. These engines are generally preferred because of their high power-to-weight ratios, but have high levels of emissions due to the two-cycle combustion process. For environmentally-sensitive areas, one alternative is to equip snowmobiles with four-stroke engines.

For this program, Yellowstone National Park (YNP) and the Montana Department of Environmental Quality (DEQ) contracted with Southwest Research Institute (SwRI[®]) to perform emissions testing of two commercially-available four-stroke snowmobiles, as well as up to five snowmobiles that participated in the 2002 SAE Clean Snowmobile Challenge (CSC), held March 23-29, 2002, in Jackson Hole, Wyoming. The objective was to measure the emissions from commercially-available, four-stroke snowmobiles, and student-designed snowmobiles with additional emissions reduction technology, and to compare these results with previously measured two-stroke snowmobile emission data.

II. DESCRIPTION OF PROGRAM

A. Test Vehicles

Currently, YNP has a large number of snowmobiles in their winter fleet with a majority of the vehicles being powered by two-stroke engines. Snowmobiles are used throughout the park for winter recreation, utility applications, and winter transport. YNP recently bought several commercially-available Arctic Cat 4-Stroke Touring snowmobiles, and several prototype 2002 Polaris 4-Stroke Frontier snowmobiles to evaluate their potential for use in park operations. One of each was also purchased for use in this test program. The Arctic Car was available as a production sled in the 2001-2002 winter season, while the Polaris was a prototype. Because of uncertainty over possible technology changes from a prototype to a production machine, the National Park Service chose to contract for only engine dynamometer testing on the Polaris, versus both engine and chassis dynamometer testing for the Arctic Cat. Table 1 describes these two commercially-available snowmobiles.

TABLE 1. DESCRIPTION OF COMMERCIALY-AVAILABLE SNOWMOBILES

Snowmobile Manufacturer	Arctic Cat	Polaris
Snowmobile Model	2002 4-Stroke Touring	2002 Frontier
Engine Manufacturer	Suzuki	Fuji
Engine Model	N/A	S2220-7868PL7D
Operating Cycle	4-stroke	4-stroke
Engine Displacement, cc	658	784
Cylinders	3	2
Cooling	Liquid	Liquid
Fuel System	EFI	EFI
Ignition System	Digital	CDI
Exhaust Aftertreatment	None	None

Both engines are equipped with electronic fuel injection (EFI), closed-loop feedback control, and altitude compensation. YNP delivered an Arctic Cat snowmobile and a Polaris Frontier engine to SwRI for testing. Both engines had never been run in the field, and required break-in prior to testing.

Five teams from the 2002 CSC were invited to have their sled's emissions tested at SwRI. Due to various factors, only two teams, Kettering University and the University of Idaho, were able to participate. Table 2 describes the two student-designed snowmobiles that were tested.

TABLE 2. 2002 CSC SUPPLEMENTAL EMISSION TESTING PARTICIPANTS

School Name	Kettering University	University of Idaho
Snowmobile Manufacturer	Yamaha	Arctic Cat
Snowmobile Model	2000 V-Max	2001 ZR
Engine Manufacturer	Daihatsu	BMW K-75
Operating Cycle	Turbocharged 4-stroke	4-stroke
Engine Displacement, cc	659	750
Cylinders	3	3
Cooling	Liquid	Liquid
Fuel System	EFI	EFI
Exhaust Aftertreatment	Three-way Catalyst	Three-way Catalyst

The two CSC snowmobiles were brought to SwRI by the participating schools to be tested on a snowmobile chassis dynamometer. Each student-designed snowmobile was set up in accordance with the CSC 2002 rules, and fueled with E10/gasohol (90% EEE certification-grade gasoline, 10% ethanol). The Kettering sled was also tested on E85 fuel (85% ethanol, 15% EEE).

B. Test Program

The program involved a combination of vehicle (snowmobile) testing performed on a snowmobile chassis dynamometer, and engine testing performed on an engine dynamometer. An advantage to testing the vehicle on a chassis dynamometer is that it incorporates all losses through the power transmission system including continuously-variable transmission (CVT), intermediate chain-driven shafts, slide rail suspension, and track. Prior to testing, each of the commercially-available snowmobile engines was broken-in. The Arctic Cat snowmobile was broken-in on the chassis dynamometer following the 600 mile break-in procedure published by Arctic Cat.(1) The Polaris engine was broken in on the engine dynamometer following a procedure similar to that used with the Arctic Cat. A complete record of the break-ins is in Appendix A. Upon completion of break-in, each engine received an oil and filter change.

The program involved testing with both engine and chassis dynamometers using several test cycles. To allow for an accurate comparison of emission results with previously accumulated data, the five-mode steady-state industry-standard snowmobile emission test cycle was used for engine dynamometer testing. This cycle was developed by SwRI for the International Snowmobile Manufacturers Association (ISMA), based on data taken during in-field operation of several makes of snowmobiles (2). This engine test cycle is shown in Table 3.

TABLE 3. ISMA/SwRI SNOWMOBILE ENGINE TEST CYCLE

Mode	1	2	3	4	5
Engine Speed, %	100	85	75	65	Idle
Engine Torque, %	100	51	33	19	0
Wt. Factor, %	12	27	25	31	5

Since the chassis dynamometer cannot accurately control low loadings, a modified four-mode chassis dynamometer test cycle was previously developed (3). This cycle is based on the five-mode procedure outlined above, with mode 4 eliminated and its weight factor proportionally reassigned to the remaining modes. The modified test cycle is shown in Table 4. Test modes are run in order, from highest to lowest speed. One hundred percent engine speed is defined as the maximum steady engine speed, at wide-open throttle, in snowmobile operation.

TABLE 4. FOUR-MODE SNOWMOBILE CHASSIS DYNAMOMETER TEST CYCLE

Mode	1	2	3	4
Engine Speed, %	100	85	75	Idle
Engine Torque, %	100	51	33	0
Wt. Factor, %	18	39	36	7

In addition to the above two cycles, YNP requested that emissions be measured at 15, 25, 35, and 45 mph, as well as at top speed, to determine g/mi emission rates. The information necessary to set the testing modes was supplied to SwRI from in-field operation, as measured by YNP personnel and CSC organizers. Snowmobiles were operated in the field at various steady speeds, and a log was made of vehicle versus engine speeds, as read from the snowmobile's gauges. These data were used to setup snowmobile operation on the chassis dynamometer. This information is presented in Appendix B.

Effects of using oxygenated fuels were also examined. These fuels have been shown to provide significant reductions in carbon monoxide (CO) concentrations in cities participating in the oxyfuel program.(4) In many environmentally-sensitive areas, oxygenated fuels with up to 10 percent ethanol are available at fueling stations. For this reason, comparison tests using E10 were also run on the commercially-available engines. A matrix of the tests performed is outlined in Table 5.

TABLE 5. TEST MATRIX

Test No.	Vehicle	Fuel	Dynamometer	Test Cycle ^a
AC-Sled-1	Arctic Cat 4s	EEE	Chassis	VS
AC-Sled-2	Arctic Cat 4s	EEE	Chassis	4m
AC-EEE-1	Arctic Cat 4s	EEE	Engine	5m
AC-EEE-2	Arctic Cat 4s	EEE	Engine	5m
AC-GHOL-1	Arctic Cat 4s	E10	Engine	5m
AC-GHOL-2	Arctic Cat 4s	E10	Engine	5m
P-EEE-1	Polaris 4s	EEE	Engine	5m
P-EEE-2	Polaris 4s	EEE	Engine	5m
P-GHOL-1	Polaris 4s	E10	Engine	5m
P-GHOL-2	Polaris 4s	E10	Engine	5m
UI-GHOL-1	Univ. of Idaho	E10	Chassis	VS
UI-GHOL-2	Univ. of Idaho	E10	Chassis	4m
KETT-GHOL-1	Kettering Univ.	E10	Chassis	VS
KETT-GHOL-2	Kettering Univ.	E10	Chassis	4m
KETT-E85-5m	Kettering Univ.	E85	Chassis	VS
KETT-E85-4m	Kettering Univ.	E85	Chassis	4m

^a VS is the five individual snowmobile speeds, 4m is the four-mode modified chassis cycle, and 5m is the five-mode engine cycle.

Fuel analysis data are shown in Table 6. Each engine was filled with the manufacturer-recommended lubricant. Arctic Cat specifies any four-cycle engine oil can be used, provided that the multi-grade oil is calibrated for the ambient temperatures the engine is to be run in. Polaris recommends a full-synthetic oil. Engine oil characterization is presented in Table 7.

TABLE 6. TEST FUEL PROPERTIES

Fuel Property	Method	Reference Gasoline (EEE)	E10	E85
Specific Gravity	ASTM D-4052	0.7432	0.7469	0.8026
RVP, psi	ASTM D-5191	8.73	10.66	4.93
Aromatics, vol.%	ASTM D-1319	38.1	27.9	3.9
Olefins		0.9	0.2	0.9
Saturates		61.0	62.2	7.0
EtOH, vol.%	ASTM D-4815	<0.05	9.65	88.2
Carbon, wt.%	ASTM D-5291	86.34	81.68	54.41
Hydrogen, wt.%		13.22	13.28	12.84
Sulfur, wt.%	ASTM D-2622	<0.001	<0.001	<0.001
Benzene, vol.%	ASTM D-3606	0.44	0.32	NA
Toluene, vol.%		20.01	14.56	NA
Benzene, wt.%	ASTM D-5580	NA	NA	0.07
Toluene, wt.%		NA	NA	2.99
Lead Content, g/gal U.S.	ASTM D-3237	<0.001	<0.001	<0.001
Phosphorous, g/gal U.S.	ASTM D-3231	0.00	0.0003	0.0001
RON	ASTM D-2699	97.0	100.3	>100.0
MON	ASTM D-2700	88.9	90.0	>100.0
Distillation, °F	ASTM D-86			
IBP		92	90	138
5 %		115	111	159
10 %		129	121	166
20 %		152	134	170
50 %		222	197	172
80 %		270	263	173
90 %		321	313	173
95 %		342	338	174
FBP		402	386	283
Recovery, %		98.0	97.8	98.2
Residue, %		0.6	0.5	0.6
Loss, %		1.4	1.7	1.2

TABLE 7. LABORATORY ANALYSIS OF 4-CYCLE ENGINE OILS

Property	Method	Texaco 15W-40 4-Cycle Engine Oil	Polaris Premium 40W-40 4-Cycle Engine Oil
Specific Gravity	ASTM D-4052	0.8780	0.8534
Viscosity @ 40 °C, cSt	ASTM D-445	107.0	78.1
Viscosity @ 100 °C, cSt	ASTM D-445	14.4	14.64
Flash Point, °C	ASTM D-92	183.9	202.2
Total Base Number	ASTM D-4739	8.15	6.98
Total Acid Number	ASTM D-664	1.81	1.70
Carbon, wt.%	ASTM D-5291	84.68	83.32
Hydrogen, wt.%		13.66	13.97
Ba, ppm	ASTM D-5185	<1.00	<1.00
Ca, ppm		3044	2212
Mg, ppm		13	345
Mn, ppm		<1.00	<1.00
Na, ppm		<5.00	<5.00
P, ppm		1208	1020
Zn, ppm		1285	1338
Distillation by GC, °C		ASTM D-2887	
IBP	319.2		322.3
5%	365.3		373.9
10%	380.5		387.2
20%	401.4		399.6
50%	445.4		428.0
80%	489.5		458.7
90%	513.3		476.4
95%	578.0		525.8
FBP	743.6	742.8	

C. Test Equipment

Snowmobile and engine testing occurred in SwRI's nonroad engine test cell. For engine testing, the engines were installed on a bed plate using factory motor mounts secured to jack stands. The engines were directly coupled to an engine dynamometer using appropriate couplings. Each engine was operated with all vehicle systems in place, including exhaust pipe and muffler, intake air box, and silencer.

Emissions were measured from proportional bag samples of diluted exhaust to determine total hydrocarbon (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), and carbon dioxide (CO₂). Particulate matter (PM) was measured using 90 mm Pallflex filtration of double-diluted exhaust following 40 CFR Part 86, Subpart N protocols. The constant-volume sampling (CVS) system and secondary dilution tunnel are shown in Figure 1.

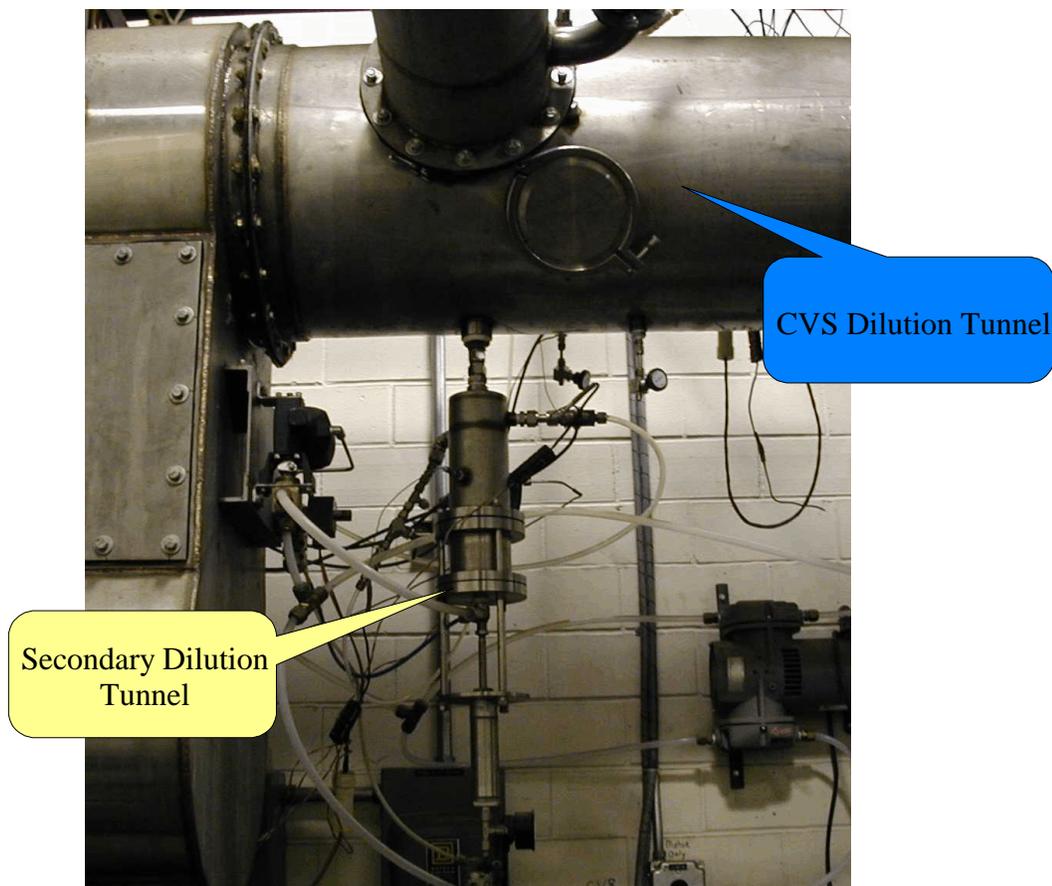


FIGURE 1. SECONDARY DILUTION TUNNEL ATTACHED TO PRIMARY DILUTION TUNNEL

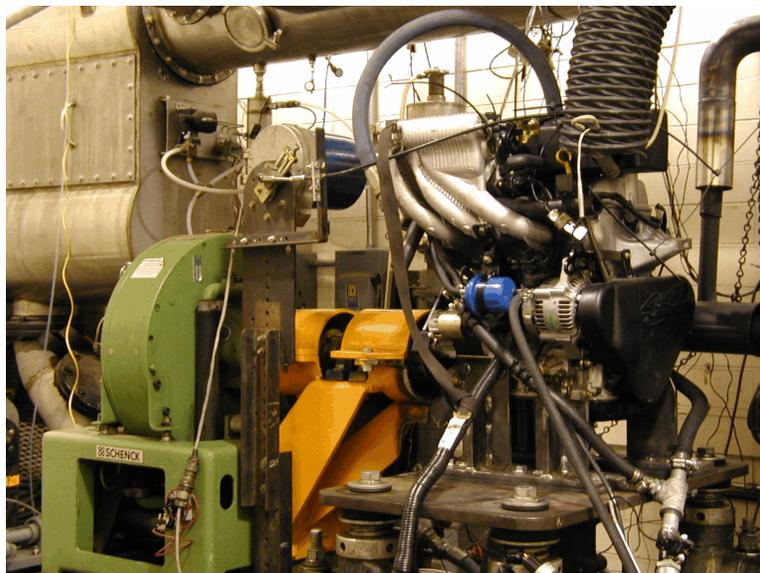
Instrumentation used included a heated flame ionization detector (HFID) for HC, non-dispersive infrared (NDIR) analyzers for CO and CO₂, and a chemiluminescent analyzer for NO_x. Flow rates were maintained in the 18 in. diameter primary dilution tunnel at approximately 1000 scfm, and 2.15 scfm in the secondary dilution system.

Chassis dynamometer testing used a Dynojet Research Inc. dynamometer with an air-cooled eddy-current absorber, capable of absorbing 875 lb-ft. of torque. It was directly coupled to the snowmobile's track through a modified undercarriage. The dynamometer control computer performs closed-loop control so that the sled can be held at a selected steady-state vehicle speed, track torque, or engine speed. The chassis dynamometer is shown in Figure 2 with the Arctic Cat test sled installed.



FIGURE 2. DYNOJET CHASSIS DYNAMOMETER

The engine dynamometer used to test the Arctic Cat and Polaris snowmobile engines was a Schenck Model W130 175 hp low-inertia, eddy-current dynamometer with a closed-loop controller developed by SwRI. Figure 3 shows the Arctic Cat 4-stroke engine coupled to the engine dynamometer.



**FIGURE 3. ARCTIC CAT SNOWMOBILE ENGINE
COUPLED TO SCHENCK DYNAMOMETER**

D. Hydrocarbon Speciation Methodology

Analytical procedures for conducting hydrocarbon speciation (C_1 to C_{12} hydrocarbons, aldehydes, and ketones) were similar to the CRC Auto/Oil Phase II methods.(5) With these methods, exhaust and evaporative emissions samples are analyzed for the presence of more than 200 different exhaust species. Three GC procedures and one High Performance Liquid Chromatograph (HPLC) procedure were used to identify and quantify specific compounds. One GC is used for the measurement of C_1 - C_4 species, and a second GC for C_5 - C_{12} species. A third GC is used to measure 1-methylcyclopentane, benzene, toluene, and 2,3,3-trimethylpentane, which co-elute and cannot be accurately quantified by other methods. In general, all emission “sample” bags were analyzed before the “background” bags, so that reactive exhaust compounds could be analyzed as quickly as possible. A brief description of these procedures is given below.

1. C_1 - C_4 Species

With the aid of a DB-WAX pre-column and a 10-port switching valve, the first GC procedure allowed the separation and determination of exhaust concentrations of C_1 - C_4 individual hydrocarbon species, including: methane; ethane; ethylene; acetylene; propane; propylene; propadiene; butane; trans-2-butene; 1-butene; 2-methylpropene; 2,2-dimethylpropane; propyne; 1,3-butadiene; 2-methylpropane; 1-butyne; and cis-2-butene. Bag samples were analyzed with a GC system which utilized a Hewlett-Packard Model 5890 Series II GC with an FID, two pneumatically operated and electrically controlled valves, and two analytical columns. The carrier gas was helium. The C_1 - C_4 hydrocarbons were separated from the higher weight hydrocarbons and polar compounds. The higher molecular weight hydrocarbons (and water and alcohols) were retained on the pre-column while the C_1 - C_4 hydrocarbons passed through to the analytical column. While the C_1 - C_4 hydrocarbons were separated on the analytical column, the pre-column was back-flushed with helium to prepare for the next run. Because the sample went directly from the sampling valve to the column (without passing through a split/split less injector), the amount of sample delivered to the column was determined by the size of the sample loop and its temperature. The column flow was set by fine-tuning the column head pressure to give butane a retention time of 5.25 ± 0.05 minutes. The GC was calibrated daily using a CRC Auto/Oil 23-component calibration mixture. Detection limits for the procedure are on the order of 5 ppbC in dilute exhaust for all compounds.

2. C_5 - C_{12} Species

The second GC procedure provided separation and exhaust concentrations for more than 100 C_5 - C_{12} individual hydrocarbon compounds. Bag samples were analyzed using a gas chromatograph equipped with an FID. The GC system utilized a Hewlett-Packard Model 5890 Series II GC with an FID, a pneumatically operated and electrically controlled valve, and a DB-1 fused silica open tubular column (FSOT). The carrier gas was helium. Gaseous sample was pumped from the bag through a sample loop on the gas sampling valve and was then introduced into a liquid nitrogen cooled column. The column oven temperature was then ramped up to a maximum of 200°C. The analog signal from the FID was sent to a networked computer system via a buffered analog to digital

converter. Column flow was set by fine-tuning the column head pressure to give propane a retention time of 5.40 ± 0.10 minutes using a temperature program. The GC was calibrated daily using a CRC Auto/Oil 23-component calibration mixture. Detection limits for the procedure are on the order of 10 ppbC in dilute exhaust for all compounds. Benzene and toluene were measured using the concentration peaks from the C₅-C₁₂ GC.

3. Aldehydes and Ketones

An HPLC procedure was utilized for the analysis of aldehydes and ketones. Samples were collected by bubbling dilute exhaust at a nominal flowrate of 4 L/min through chilled glass impingers containing an acetonitrile solution of 2,4-dinitrophenylhydrazine (DNPH) and perchloric acid. For analysis, a portion of the acetonitrile solution was injected into a liquid chromatograph equipped with a UV detector. External standards of the aldehyde and ketone DNPH derivatives were used to quantify the results. The aldehydes and ketones measured were: formaldehyde, acetaldehyde, acrolein, acetone, propionaldehyde, crotonaldehyde, isobutyraldehyde/methylethylketone (not resolved from each other during normal operating conditions, and so split equally between the two compounds), benzaldehyde, valeraldehyde, o-tolualdehyde, m-tolualdehyde/p-tolualdehyde (not resolved from each other during normal operating conditions, and so reported together), and hexanaldehyde. Detection limits for this procedure are on the order of 0.005 ppm aldehyde or ketone in dilute exhaust.

4. Alcohols

The measurement of alcohols and ethers in exhaust was accomplished by bubbling the exhaust through glass impingers containing deionized water. Two glass impingers in series, with each containing 25 mL of deionized water were used to collect exhaust samples for the analysis. The two glass impingers collect 99+ percent of the lower molecular weight alcohols. The temperature of the collection impingers was maintained at 0-5°C with an ice water bath, and the flow rate through the impingers was maintained at 4L/minute by the sample pump. A dry gas meter was used to determine the total flow through the impingers. The temperature of the gas stream was monitored by a thermocouple immediately prior to the dry gas meter. A drier was included in the system to prevent condensation in the pump, flowmeter, dry gas meter, etc. The flowmeter in the system allowed continuous monitoring of the sample to ensure proper flowrates during sampling. The Teflon line connecting the CVS and the sample control solenoid valve was heated to approximately 235°F in order to prevent water from condensing in the sample line.

An exhaust sample was collected during each test mode. Upon completion of each steady-state mode, the impingers were removed, and the contents were transferred to a 30mL polypropylene bottle, and capped. For analysis, a 0.5 μ L portion of the aqueous solution was injected into a Hewlett-Packard 5890 GC equipped with a FID and a 7673 auto sampler. The analytical column was a 0.32 mm X 30 m DB-WAX column with a 0.5 μ m film thickness. The carrier gas was helium and was set to give optimum separation (~7mL/minute). To quantify the results, the sample peak areas were compared to the peak areas of standard solutions. External standards containing five different common alcohols (methanol, ethanol, 1-propanol, 2-propanol, and tertiary butanol) in deionized water were used to quantify the results. Detection limits for the lower molecular weight alcohols with this procedure are on the order of 0.06 ppm in dilute exhaust.

III. RESULTS AND DISCUSSION

A. Arctic Cat and Polaris 4-Stroke Snowmobile and Engine Testing

The Arctic Cat 4-Stroke Touring snowmobile was first tested on the chassis dynamometer, and then its engine was removed and tested on the engine dynamometer. The Polaris engine was tested only on the engine dynamometer. Figure 4 shows results of chassis dynamometer testing of the Arctic Cat engine over the four-mode snowmobile chassis dynamometer test cycle. Four-mode composite emissions were 7.23 g/hp-hr HC, 160 g/hp-hr CO, 11.8 g/hp-hr NO_x, and 0.11 g/hp-hr PM. A complete set of modal and composite emission results are presented in Appendix C.

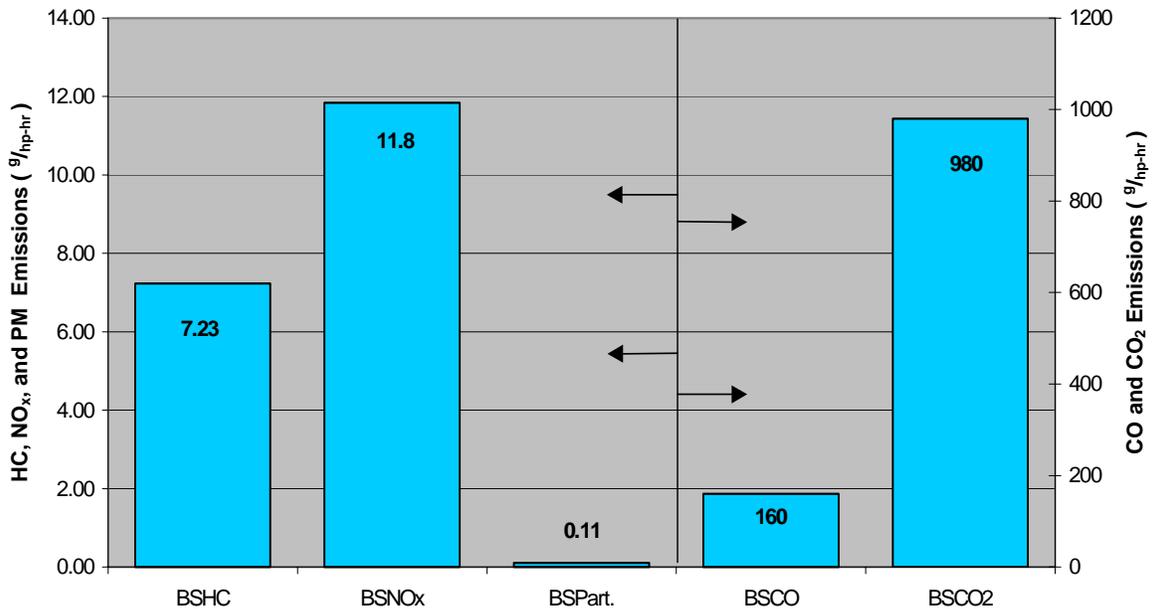


FIGURE 4. ARCTIC CAT FOUR-MODE COMPOSITE CHASSIS DYNAMOMETER EMISSION RESULTS

As a point of reference, a conventional 2-stroke powered snowmobile was tested at Flagg Ranch, Wyoming during CSC 2001 using the same test procedure.(3) It was a 2001 Polaris Sport Touring snowmobile that served as a reference for the emissions event. Composite 4-mode emissions were 132.7 g/hp-hr HC, 1136 g/hp-hr CO, and 1.73 g/hp-hr NO_x. Compared to this reference 2-stroke, Arctic Cat HC and CO emissions were 95 percent and 86 percent less, respectively. Arctic Cat NO_x emissions, however, were higher by a factor of seven.

The Arctic Cat sled was also tested at various vehicle speeds to determine g/mile emissions. Table 8 shows HC, CO, NO_x, PM, and CO₂ emissions results for various vehicle speeds. Additional vehicle speed results are available in Appendix C. Chassis dynamometer testing was accomplished by loading the snowmobile to achieve target

engine speeds for the corresponding vehicle speed. The maximum vehicle speed, as measured in the field during full-throttle operation, was 50 miles per hour (mph). Around 15 mph, the engine seemed to be running richer than during full-throttle operation. It is not known what caused this condition, but it was difficult to maintain 15 mph steady-state operation.

TABLE 8. ARCTIC CAT SNOWMOBILE EMISSIONS VS. VEHICLE SPEED

Vehicle Speed (mph)	Emissions, g/mi				
	HC	CO	NO _x	PM	CO ₂
50 (max)	3.28	138.9	2.42	0.05	410
45	2.56	51.8	6.15	0.02	399
35	2.28	36.5	4.93	0.03	331
25	2.40	17.8	6.38	0.04	364
15	3.04	28.8	5.25	0.07	424

After completing chassis dynamometer testing, the Arctic Cat engine was removed from the snowmobile and installed on the engine dynamometer. Figure 5 shows the composite five-mode ISMA/SwRI cycle engine dynamometer results using both EEE reference gasoline and E10. As expected, E10 causes the engine to run slightly leaner, thus producing less power and CO emissions, and higher NO_x emissions. It was noticed that the Arctic Cat engine was very sensitive to changes in fuel pressure, especially when running on E10. For this reason, the external fuel flow metering device was removed during E10 testing. In addition, when running at steady-state conditions using E10, the engine would stumble and lose power without recovery. This triggered a fault with the engine controller, requiring the power to the engine control module (ECM) to be cycled to clear the fault from memory. This problem was not experienced with EEE fuel, even after the problem occurred with E10. Prior to testing, YNP technicians notified SwRI about an Arctic Cat recall of the exhaust gas oxygen (EGO) sensor. At the time of testing, no replacement sensors were available. To determine if the EGO sensor was at fault, an automotive EGO sensor was installed. Operation with this component produced the same results, leading to belief that the stumble was due to inadequate fuel flow. Therefore, the rear fuel pick-up from the "T" inside the fuel tank was removed to allow an increased volume of fuel to be pumped to the engine. After the fuel pick-up was removed, the stumbling problem was no longer experienced.

Figure 6 presents emission results of the Polaris 4-stroke engine tested on the engine dynamometer. Similar to the Arctic Cat, the Polaris 4-stroke engine produced less CO and NO_x emissions using E10, as compared to reference gasoline. The Polaris engine produced the same power running on E10 as with gasoline, compensating better than the Arctic Cat engine for the fuel differences.

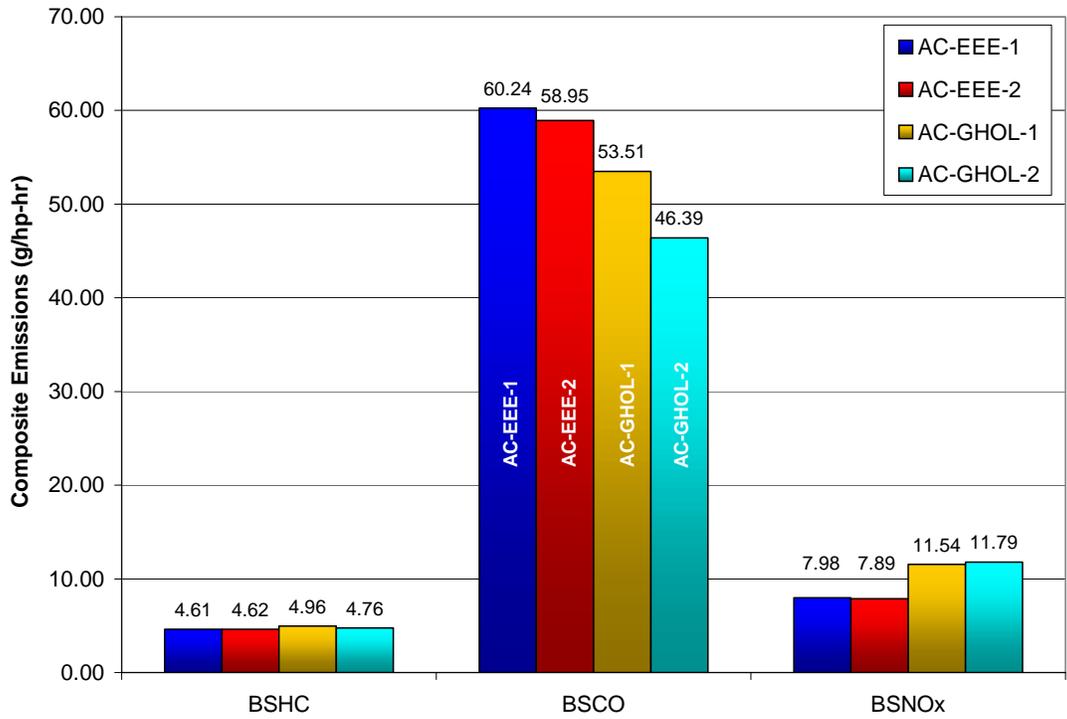


FIGURE 5. ARCTIC CAT ENGINE DYNAMOMETER EMISSION RESULTS

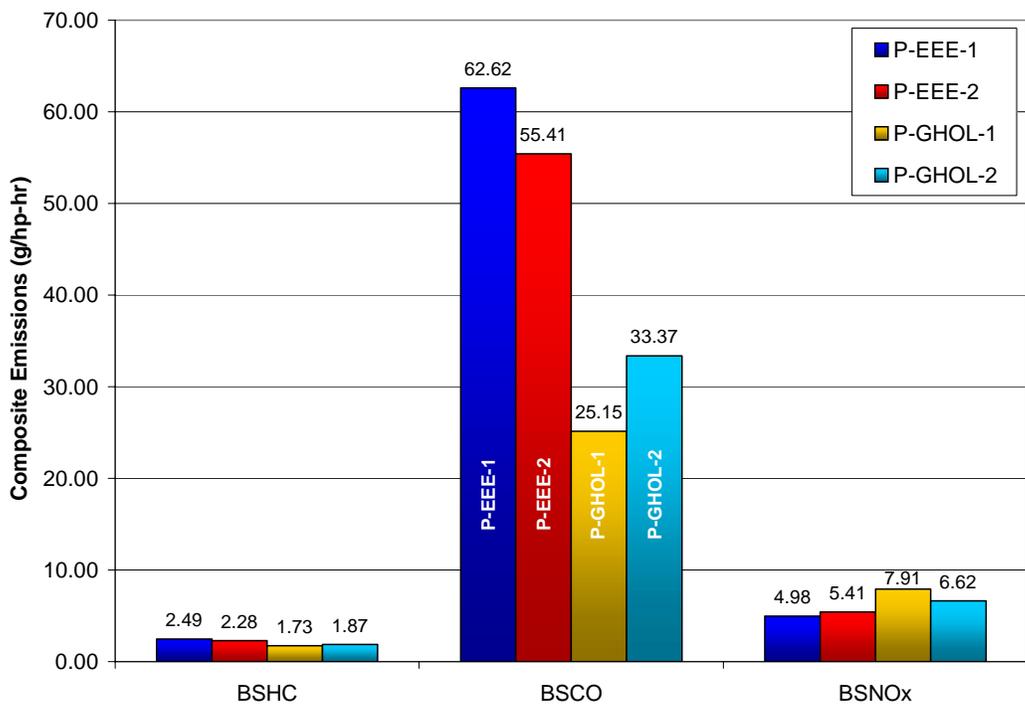


FIGURE 6. POLARIS ENGINE DYNAMOMETER EMISSION RESULTS

It was noticed that the first E10 test on the Polaris engine (P-GHOL-1) produced significantly lower CO and HC emissions during mode 1. It is believed that this was a result of the adaptive-learn system not yet having adjusted to run on the new fuel, causing the engine to run slightly leaner in mode 1 of the first E10 test. The closed-loop adaptive learn system uses feedback from the EGO sensor to adjust the fuel injection rate to achieve a stoichiometric intake charge. Mode 1 emissions of the second E10 test (P-GHOL-2) are probably more representative of the Polaris engine’s full-throttle E10 operation.

Figure 7 summarizes particulate matter results from Arctic Cat and Polaris engine testing. These four-stroke engines produce very small quantities of PM compared to two-stroke snowmobile engines, which typically produce >1.00 g/hp-hr of PM over the 5-mode ISMA/SwRI test cycle. Both the Polaris and Arctic Cat engines generated approximately 0.07 g/hp-hr of PM over the 5-mode test cycle. Differences in PM emissions between the two fuels are not likely significant.

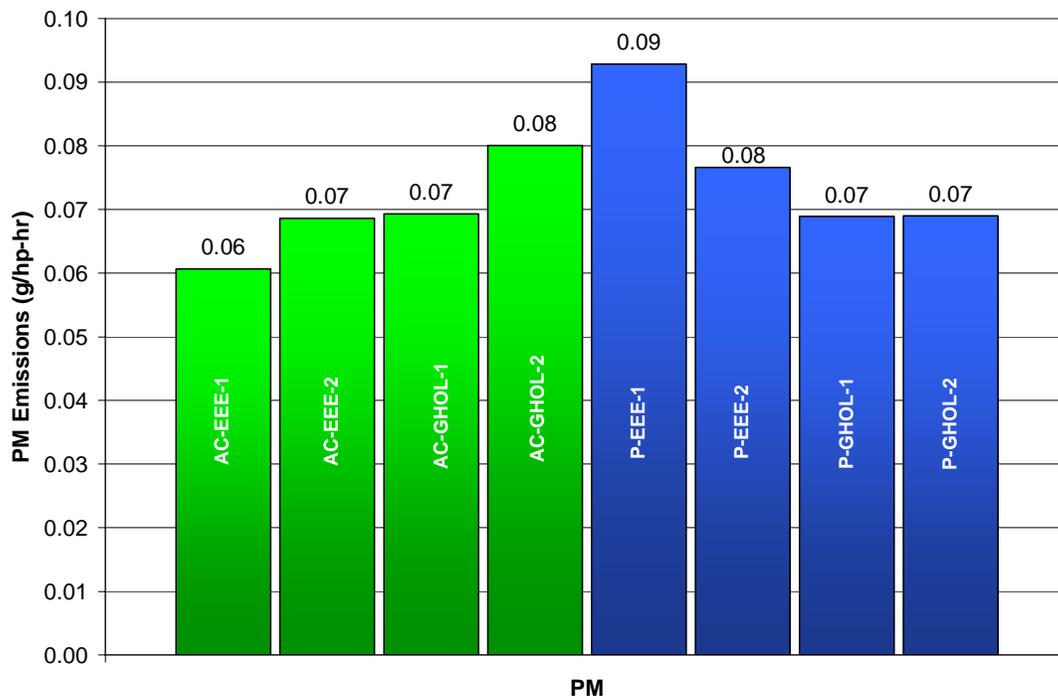


FIGURE 7. ARCTIC CAT AND POLARIS ENGINE DYNAMOMETER PM RESULTS

These results are compared with those of previously-tested 2-stroke snowmobiles in Table 9. Based on mean results, the 4-stroke snowmobile engines emitted 98 percent less HC, 85 percent less CO, and 96 percent less PM. Four-stroke NO_x emissions were higher than the 2-strokes by a factor of 12. Four-stroke fuel consumption was 40 percent less than that of the 2-strokes.

TABLE 9. TWO-STROKE VS. 4-STROKE SNOWMOBILE ENGINE EMISSIONS AND FUEL CONSUMPTION COMPARISON (EEE FUEL, 5-MODE)

Snowmobile Engine	Emissions, g/hp-hr				BSFC, lb/hp-hr
	HC	CO	NO _x	PM	
Arctic Cat 4-Stroke, mean	4.62	59.6	7.93	0.065	0.602
Polaris 4-Stroke, mean	2.38	59.0	5.20	0.085	0.694
4-Stroke, mean	3.50	59.3	6.57	0.075	0.648
Arctic Cat 2-Stroke ^a	156.0	363.4	0.49	3.46	1.10
Polaris 2-Stroke ^b	150.7	416.4	0.44	1.35	1.05
500 cc 2-Stroke ^c	115.5	375.6	0.69	0.70	NA
2-Stroke, mean	140.7	385.1	0.54	1.84	1.08

^a SAE 972108, 440 cc engine from 1995 Panther, mean gasoline result (6)
^b SAE 972108, 488 cc engine from 1997 Indy Trail, mean gasoline result (6)
^c SAE 2000-01-2003, 500 cc 2-stroke, weighted base total result

YNP also requested an estimate of snowmobile emissions in grams per mile. Emission rates were calculated from engine dynamometer emissions using curve-fitting and interpolation. These results were calculated using the unweighted mass emissions results from engine testing, based on the procedure described below.

$$\text{Mass Emissions (g/mi)} = \frac{M}{V}$$

where: M = mass emissions (g/hr) V = vehicle speed (mph)

A vehicle speed (V) matching each mode of the ISMA/SwRI 5-mode test cycle, was determined by interpolation of the snowmobile engine speed vs. vehicle speed data presented in Appendix B. The mass emissions (M) variable represents the unweighted g/hr emission rates measured at each of the five engine speeds. A second-order curve was then generated to fit the calculated modal emission rates (g/mi) and vehicle speeds. The curve was then used to calculate g/mi emission rates at 15, 25, 35, and 45 mph, as well as at top speed. These curves are shown in Figures 8, 9, 10 and 11. Since snowmobiles use CVTs, the final drive gear ratio changes continually, which can affect estimated vehicle speed. Table 10 summarizes estimated snowmobile emissions in grams per mile. Appendix D shows the data and calculations used to estimate these results.

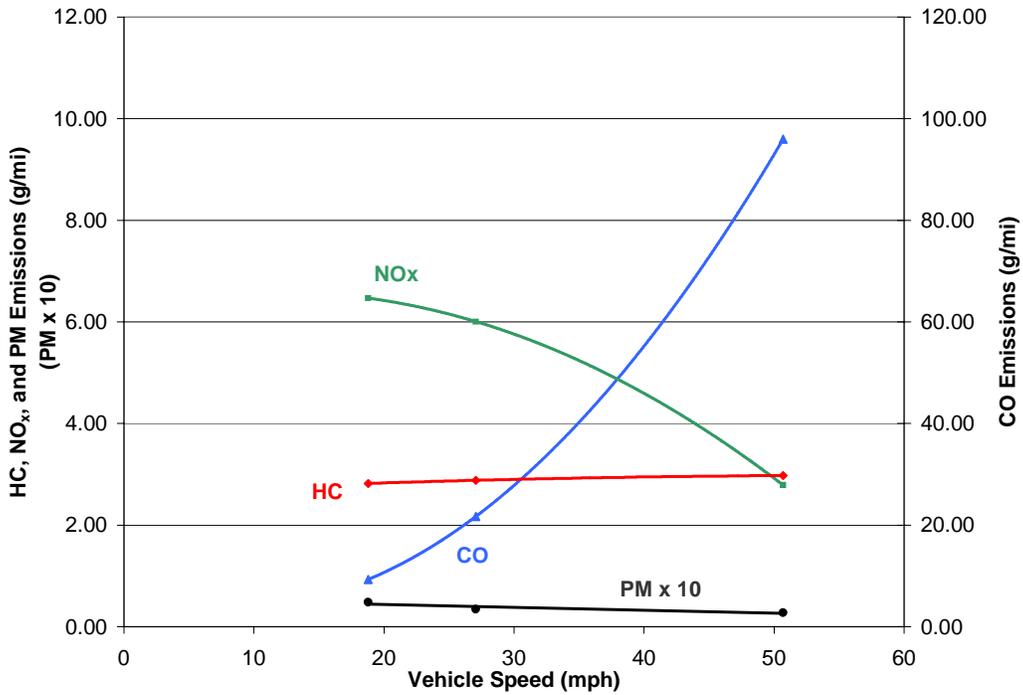


FIGURE 8. ESTIMATED ARCTIC CAT SNOWMOBILE EMISSIONS, G/MI (GASOLINE)

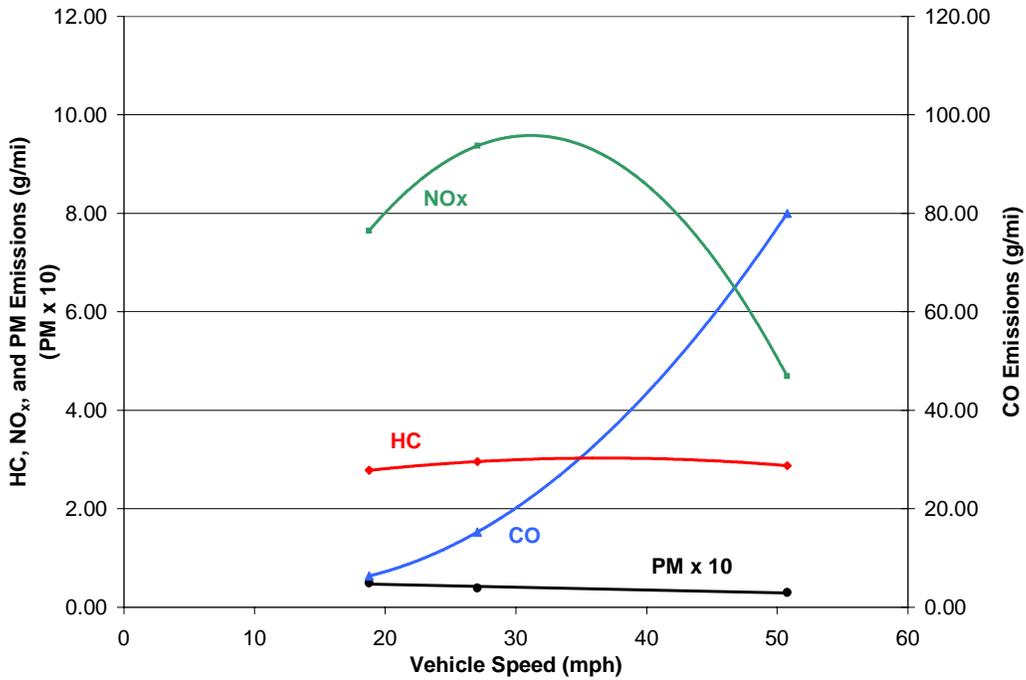


FIGURE 9. ESTIMATED ARCTIC CAT SNOWMOBILE EMISSIONS, G/MI (E10)

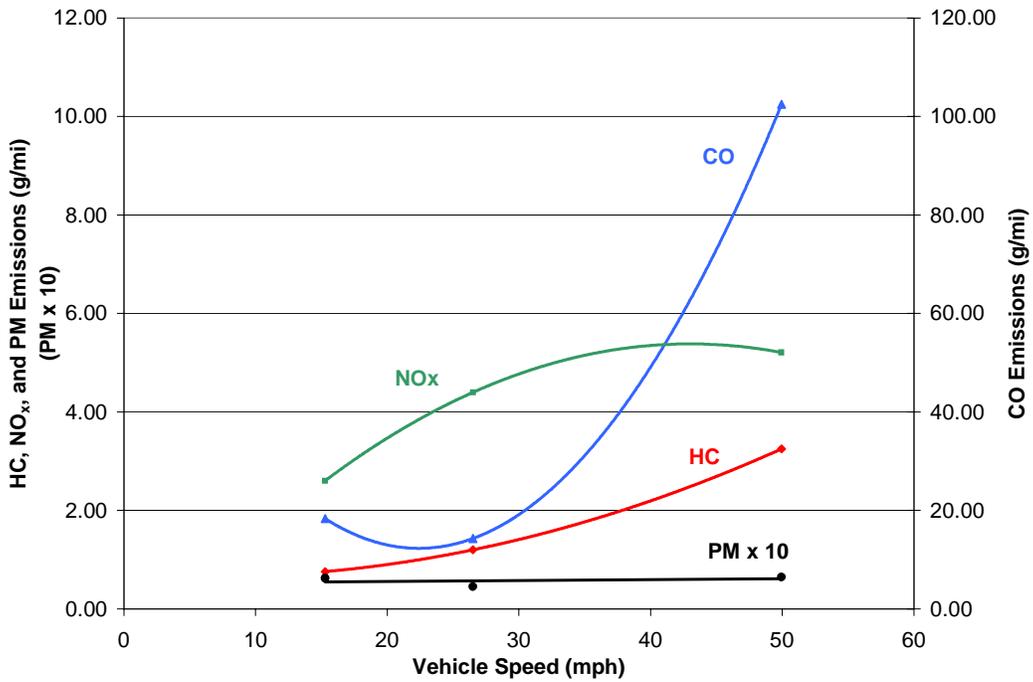


FIGURE 10. ESTIMATED POLARIS SNOWMOBILE EMISSIONS, G/MI (GASOLINE)

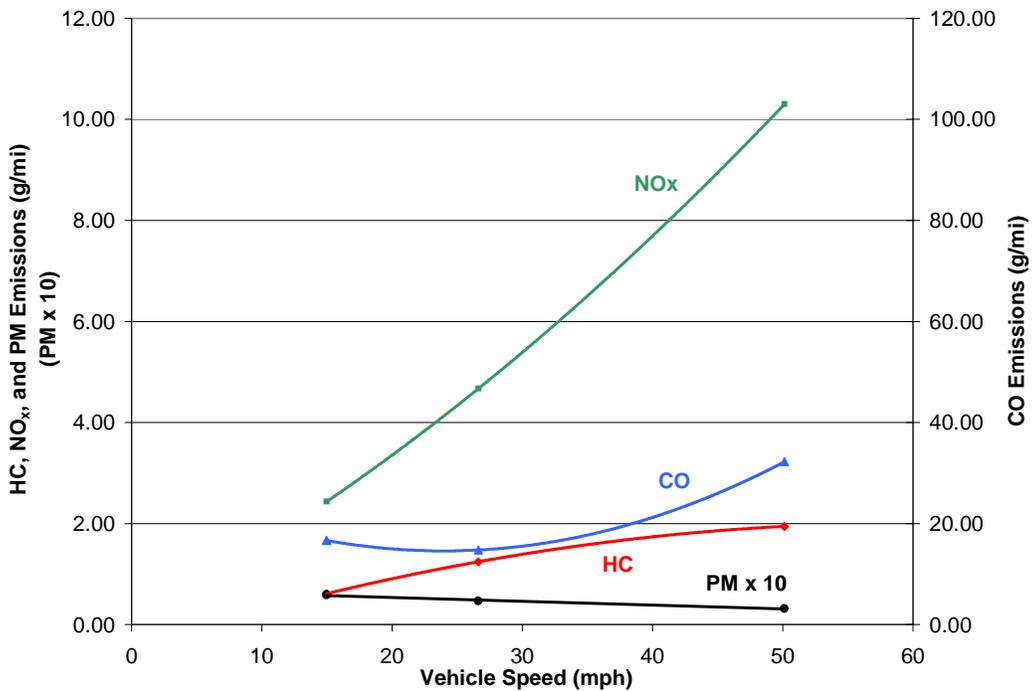


FIGURE 11. ESTIMATED POLARIS SNOWMOBILE EMISSIONS G/MI (E10)

TABLE 10. ESTIMATED SNOWMOBILE EMISSIONS, G/MI

Test Number	Vehicle Speed, mph	Emissions, g/mi			
		HC	CO	NO _x	PM
Polaris Gasoline	50	3.30	103	5.24	0.06
	45	2.72	73	5.40	0.06
	35	1.79	31	5.17	0.06
	25	1.13	13	4.22	0.06
	15	0.75	19	2.55	0.05
Polaris E10	50	1.94	32	10.39	0.03
	45	1.85	26	9.05	0.03
	35	1.58	18	6.57	0.04
	25	1.17	15	4.37	0.05
	15	0.61	17	2.45	0.06
Arctic Cat Gasoline	50	2.99	93	2.98	0.03
	45	2.98	73	3.87	0.03
	35	2.94	40	5.27	0.03
	25	2.87	18	6.17	0.04
	15	2.79	6	6.57	0.05
Arctic Cat E10	50	2.84	77	4.99	0.03
	45	2.93	59	7.08	0.03
	35	3.00	30	9.35	0.04
	25	2.91	12	9.09	0.04
	15	2.66	5	6.28	0.05

Figure 12 compares calculated g/mi emissions to measured g/mi emissions for the Arctic Cat snowmobile. Most values agree reasonably well, given the differences between the two measurement techniques. Some of the differences may be due to inadequate chassis dynamometer loading at low sled speeds and variability of the CVT.

Table 11 compares the four-stroke snowmobile engines with various types of off-highway engines. The 2.7L utility engine does not have closed-loop control or aftertreatment. It is typical of pre-control engines (before emission standards), used in forklifts. The 2.5L Ford Power Products industrial engine has closed-loop control with a three-way catalyst in order to meet CARB and EPA large spark-ignited engine emission standards. Primary applications of the 2.5L engine are in generator sets and industrial lifts. Each set of results was generated from steady-state test cycles, however, these cycles were not identical. It is noted that very low emissions are possible with an enhanced calibration and aftertreatment.

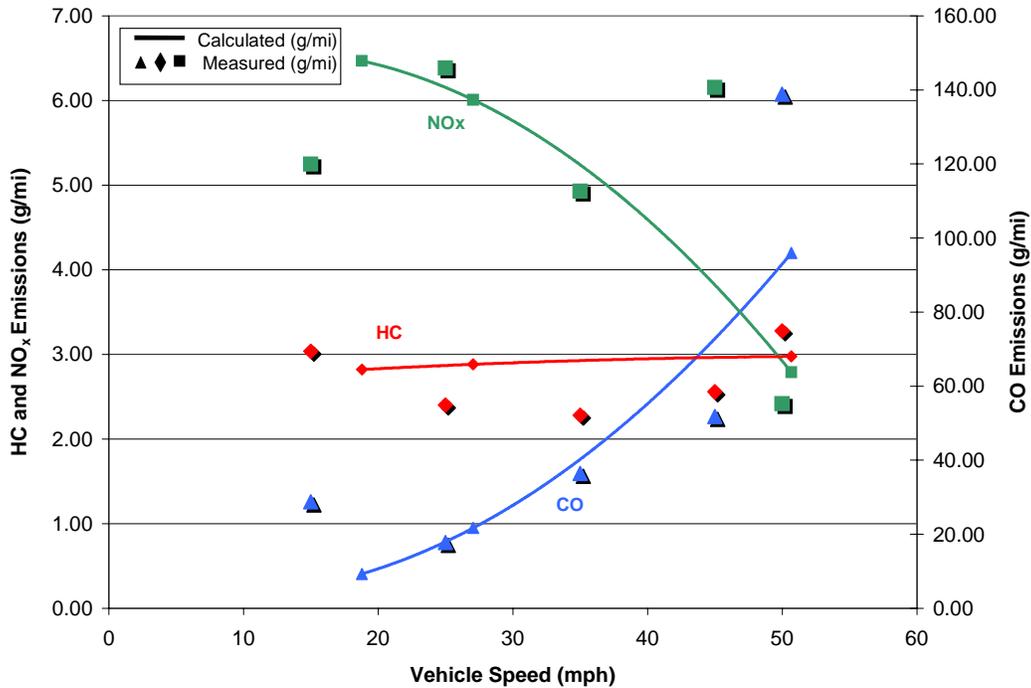


FIGURE 12. ARCTIC CAT SNOWMOBILE CALCULATED VS. MEASURED G/MI EMISSIONS COMPARISON

TABLE 11. EMISSIONS OF VARIOUS TYPES OF OFF-HIGHWAY SI ENGINES

Engine	Emissions, g/hp-hr				
	HC	CO	NO _x	PM	HC+NO _x
Arctic Cat 4-Stroke (gasoline mean)	4.62	59.6	7.93	0.07	12.6
Polaris 4-Stroke (gasoline mean)	2.38	59.0	5.20	0.09	7.58
Uncontrolled 2.7L 60 hp Gasoline SI Utility Engine ^a	2.02	126	8.30	0.02	10.3
2.5L Power Products Industrial Engine, CL control and TWC ^b	0.12	10.9	0.02	NA	0.14

^a As reported in SAE 931541 over ISO 8178-G1 cycle (7)
^b CARB certification results published by Ford Power Products over ISO 8178-C2 test cycle

Table 12 compares the four-stroke snowmobile engines to various standards for spark-ignited engines. The on-highway heavy-duty engine standard applies to engines that power medium and heavy-duty on-highway trucks. These engines typically have closed-loop, three-way catalyst systems. The large spark-ignited (LSI) engine standard covers nonroad engines >19 kW, such as forklift and industrial engines. Catalysts will be required to meet the LSI standards. The sterndrive/inboard marine standard applies to SI engines that power pleasurecraft. The 2007 standard will require the use of catalyst. The current

small engine standards do not require catalyst, although CARB is considering rulemaking that may do so in the future. It is noted that both 4-stroke snowmobile engines are significantly below the proposed snowmobile standard.

TABLE 12. SNOWMOBILE EMISSION RESULTS COMPARED TO SPARK-IGNITED ENGINE STANDARDS

Engine	Emissions, g/hp-hr			
	HC	CO	NO _x	HC+NO _x
Arctic Cat 4-Stroke (gasoline mean)	4.62	59.6	7.93	12.6
Polaris 4-Stroke (gasoline mean)	2.38	59.0	5.20	7.58
Proposed 2006 EPA Snowmobile Standards	75.0	205		
1998 EPA Heavy-Duty On-Highway SI Engines (vehicles ≤ 14,000 lb)	1.10	14.4	4.00	
2004 EPA Heavy-Duty On-Highway SI Engines (vehicles ≤ 14,000 lb)		14.4		2.4 or 2.5 ^a
2004 EPA Large Spark-Ignited Engines, >19 kW		37		3
2007 EPA Large Spark-Ignited Engines, >19 kW		2.5		2.5
2003 CARB Sterndrive/Inboard Marine Engines				11.9
2007 CARB Sterndrive/Inboard Marine Engines				3.7
2001-2005 EPA Phase II/Class II Standard for Small Nonhandheld SI Engines (>=225 cc)		387		9.02
2002 CARB Small Off-Road Engine Standard SI, >225 cc		410		9.00
^a NMHC+NO _x				

B. Arctic Cat Engine HC Speciation Results

Hydrocarbon speciation was performed on selected Arctic Cat engine tests. Emission rates of the four organic gases classified by EPA as air toxics—1,3-butadiene, benzene, formaldehyde, and acetaldehyde, are summarized in Table 13. Results show that the Arctic Cat 4-stroke engine produces approximately one-tenth of the air toxics as compared to comparable two-stroke engines.(10) As expected with the ethanol containing fuel, acetaldehyde emissions are slightly higher because the ethyl group is a direct precursor of acetaldehyde, and is readily converted to acetaldehyde through partial oxidation. Most other species emission rates were similar between the two fuels. Results from all hydrocarbon speciation tests are presented in Appendix E.

TABLE 13. HYDROCARBON SPECIATION RESULTS

Engine	Fuel	Emissions, g/hp-hr			
		1,3-Butadiene	Benzene	Formald.	Acetald.
Arctic Cat 4-Stroke	Gasoline (AC-EEE-1)	0.00	0.13	0.14	0.02
Arctic Cat 4-Stroke	E10 (AC-GHOL-1)	0.00	0.12	0.13	0.05
Arctic Cat 2-Stroke	Gasoline (W11-1) ^a	0.09	0.78	0.69	0.09
Arctic Cat 2-Stroke	E10 (W21) ^a	0.10	0.84	0.88	0.60
Polaris 2-Stroke	Gasoline (A11-3) ^a	0.22	1.26	1.12	0.15
Polaris 2-Stroke	E10 (A21) ^a	0.23	1.13	1.18	0.83

^a As reported in SwRI Final Report 7383.

C. Supplemental 2002 CSC Snowmobile Testing

Student-designed snowmobiles were tested with the chassis dynamometer. Two sets of emission tests were performed on each university's snowmobile--steady-state emissions at 15, 25, 35, and 45 mph and at maximum speed, as well as the 4-mode chassis dynamometer test cycle. Additional testing was performed on the Kettering snowmobile to evaluate potential benefits of operating on E85 (85% ethanol).

When the Kettering snowmobile was operated on the chassis dynamometer, the ECM would not allow steady-state operation for more than two minutes. This caused a fault in the ECM and required either a change of throttle position or keying-off to reset the ECM. This required adjusting the procedure by discontinuing emissions sampling, cycling power to the sled, and then resuming sampling. In addition, the Kettering snowmobile required a modification to operate on E85. The fuel pressure regulator setting was increased to provide greater fuel pressure with E85, thus enabling higher fuel flow rates.

For CSC 2001, SwRI performed emissions testing on-site at Flagg Ranch, Wyoming using the same chassis dynamometer 4-mode procedure as used in this program. Results are, therefore, directly comparable. For CSC 2000 and 2002, a different emissions measurement technique was used which determined emission concentrations with a remote sensing device using a drive-by procedure.

Table 14 shows the 4-mode chassis dynamometer results from the Kettering sled. For comparison, 2001 CSC results are included. As expected, the Kettering sled produced less HC, CO, and PM emissions with E85 due to leaner operation with the higher ethanol content fuel. Although this is the same sled and engine run at the 2001 CSC, chassis dynamometer results from the 2001 competition do not agree with 2002 results at SwRI. It is unclear why the results are so different, but it may be due to a difference in vehicle operation between tests. Tests performed at CSC 2001 used a rated engine speed of 7100 RPM, whereas Kettering stated a 6200 RPM setting for SwRI testing. Kettering also changed the catalyst used for 2002, opting to use a lighter-weight three-way catalyst. Data also indicates that the Kettering sled was running rich at modes 1 and 2 at SwRI, and richer

in general than at CSC 2001. These symptoms may indicate the Kettering sled was experiencing control problems while at SwRI.

TABLE 14. KETTERING UNIVERSITY SNOWMOBILE EMISSION RESULTS

Vehicle	Fuel	Test	Mode 1 Power, hp	Mode 1 Fuel, lb/hr	Emissions, g/hp-hr			
					BSHC	BSCO	BSNO _x	BSPM
2002 SwRI	E10	4m	35.8	42.8	5.20	382	0.17	0.12
2002 SwRI	E85	4m	39.9	69.8	2.64	241	0.14	0.05
2001 CSC	E10	4m	37.8	37.2	3.13	241	0.63	NA

Also participating in the supplemental testing was the University of Idaho. From the data presented in Table 15, it appears the Idaho sled operated significantly different during testing at SwRI as compared to CSC 2001. The vehicle produced more track power at similar engine speeds, and seemed to have a much better clutching setup than when tested during CSC 2001. After arriving in San Antonio, the Idaho sled required slight tuning of the intake mass air-flow sensor to compensate for the change in altitude. The mass-air flow sensor potentiometer was adjusted to generate approximately two percent engine-out CO, as recommended by BMW. This is the same setting used at the 2002 Clean Snowmobile Challenge.

TABLE 15. UNIVERSITY OF IDAHO SNOWMOBILE EMISSION RESULTS

Vehicle	Fuel	Test	Mode 1 Power, hp	Mode 1 Fuel, lb/hr	Emissions, g/hp-hr			
					BSHC	BSCO	BSNO _x	BSPM
Idaho 2002 SwRI	E10	4m	33.0	26.2	2.59	114	0.14	0.07
Idaho 2001 CSC	E10	4m	17.6	23.7	21.1	466	1.04	NA

Table 16 compares SwRI's laboratory emission measurements versus those measured in-field during the 2002 CSC. The in-field CSC measurement used the Fuel Efficiency Automobile Test (FEAT) apparatus, which is a remote infrared monitoring device designed to emulate a NDIR exhaust gas analyzer. The FEAT consists of an infrared source that sends a beam across the vehicle's path, and into a detector, where it is divided between four individual detectors: CO, CO₂, UHC, and reference. This device has been used for two in-use surveys of snowmobile emissions in YNP, and was also used for emissions measurement at CSC 2000.(11) Emissions were measured in two modes of operation at CSC 2002. Mode 1 was an acceleration from 0 to 15 mph, and Mode 2 was a constant speed of 25-30 mph up an 8 percent grade. The table compares full-throttle, Mode 1 operation in the field to full-throttle operation during mode 1 of the 4-mode chassis dynamometer test cycle. On-site measurements for UHC are expressed as percent propane, therefore, results are multiplied by three to represent hydrocarbon emissions on a C₁ basis. To convert the mode 1 dilute emission concentrations from the 4-mode test to raw concentrations, the dilute concentrations were multiplied by the sample dilution factor and converted to a percentage. While there is some offset between results, they seem to

indicate similar trends. The 2002 CSC procedure does discern the differences between Kettering and Idaho HC and CO emissions.

TABLE 16. LABORATORY VERSUS ON-SITE EMISSIONS MEASUREMENT OF 2002 CSC SNOWMOBILES

Vehicle	Fuel	Emissions, %		
		HC	CO	NO _x
CSC Mode 1 (Flat WOT) vs. SwRI Mode 1				
Kettering 2002 SwRI	E10	0.212	7.55	0.0002
Kettering 2002 CSC	E10	0.120	2.41	0.000
Idaho 2002 SwRI	E10	0.082	2.32	0.003
Idaho 2002 CSC	E10	0.051	1.12	-0.001
CSC Mode 2 (8% grade @ 25-35 mph)				
Kettering 2002 CVS	E10	0.099	1.27	-0.002
Idaho 2002 CSC	E10	-0.030	1.43	0.001

Table 17 compares emissions results of the three four-stroke snowmobiles tested at SwRI with chassis dynamometer results from CSC 2001. The Polaris Sport Touring sled employed a 2-stroke engine, and served as the reference for scoring student sled emission results. The Buffalo and Kettering sleds achieved the lowest composite HC+NO_x results of all the sleds tested at CSC 2001. Kettering and Idaho 2002 results are comparable to those of the best two sleds from 2001. The 2002 Idaho sled, using a three-way catalyst, generated the lowest composite results of all the sleds tested.

TABLE 17. FOUR-MODE CHASSIS DYNAMOMETER TEST RESULTS

Vehicle	Fuel	Test	After-treatment	Emissions, g/hp-hr			
				BSHC	BSCO	BSNO _x	BSPM
2002 SwRI Results							
Kettering 2002 SwRI	E10	4m	TWC	5.20	382	0.17	0.12
Idaho 2002 SwRI	E10	4m	TWC	2.59	114	0.14	0.07
Arctic Cat 4-Stroke Sled	EEE	4m	None	7.23	160	11.80	0.11
2001 CSC Results							
'01 Polaris Sport Touring (2-stroke)	E10	4m	None	132.7	1136	1.73	NA
University of Buffalo Polaris (4-stroke)	EEE	4m	Oxidation & TWC	4.18	199	0.16	NA
Kettering '00 Yamaha Diahatsu (4-stroke)	E10	4m	TWC	3.13	241	0.63	NA

IV. CONCLUSIONS AND RECOMMENDATIONS

Results demonstrate that snowmobile emissions can be significantly reduced through the use of 4-stroke engines. Further, the University of Idaho snowmobile demonstrated that even lower emissions can be achieved through the use of a catalyst. Emission reductions were also shown through use of oxygenated blends such as E10 and E85.

- Commercially-available 4-stroke snowmobiles are significantly cleaner than 2-stroke sleds. Compared to previously tested 2-stroke snowmobiles, these 4-stroke sleds emit 98-95 percent less HC, 85 percent less CO, and 90-96 percent less PM.

Four-stroke snowmobile NO_x , however, is considerably higher than from a 2-stroke, being increased by a factor of seven to twelve.

- The commercially-available 4-stroke snowmobiles emit roughly 90 percent less toxic hydrocarbons, such as 1,3-butadiene, benzene, formaldehyde, and acetaldehyde, than 2-stroke sleds.
- Four-stroke snowmobiles achieve approximately 40 percent better fuel economy than 2-stroke sleds.
- Use of a catalyst can further reduce snowmobile emissions. The University of Idaho CSC 2002 sled, which incorporates a 4-stroke, closed-loop controlled engine with catalyst, generated the lowest emissions of all sleds tested. Compared to the 4-stroke Arctic Cat sled, the Idaho sled emitted 64 percent less HC, 29 percent less CO, 99 percent less NO_x , and 36 percent less PM.
- E10 fuel reduced CO but increased NO_x for the 4-stroke snowmobiles. E10 slightly reduced Polaris HC emissions, but slightly increased Arctic Cat HC emissions.
- E85 fuel reduced HC, CO, and PM emissions on the Kettering sled, compared to E10 results.
- Arctic Cat emissions were measured using both 4-mode chassis and 5-mode engine dynamometer procedures. As expected, chassis dynamometer results were higher by ~50 percent for HC and NO_x , ~70 percent for PM, and ~160 percent for CO.

These differences are the result of differences in measured cycle work. Chassis dynamometer work is reduced due to the very significant power losses in the snowmobile drivetrain. Results above suggest a drivetrain efficiency of about 66 percent. The CO value is likely influenced by other factors, including the use of one less mode in the chassis procedure. This, along with adjustment in mode weight factors, can cause large changes in composite cycle CO results.

- While EPA's proposed snowmobile emission regulation is based on the industry-standard 5-mode engine dynamometer procedure, a case could be made that a chassis-based emission result provides a more real-world emission factor by including drivetrain losses, as mentioned above. The chassis dynamometer procedure, however, is subject to greater variability due to two factors. First, it is very difficult to control track loads at low levels, and this is the reason that mode 4 of the engine cycle is not run in the chassis procedure. Second, the chassis procedure is subject to the natural variability in operation of the CVT.
- A snowcoach emission factor was estimated in a separate project for the State of Wyoming, based on laboratory chassis dynamometer measurement of emissions from a V-10-powered Ford E-350 15 passenger van.(12) We were not able to exactly simulate conditions on the dynamometer equivalent to those seen in the field. At normal loads, the van's engine operates at stoichiometric, achieving very low emission levels. Running in snow on tracks generates tremendously higher engine loads than on-highway operation. A simulation of this on the chassis dynamometer provided a second emission value (open loop, rich), which may be more typical of real snowcoach operation.

	Emissions, g/mi		
	HC	CO	NO _x
Ford van, closed-loop, stoichiometric	0.044	0.76	0.54
Ford van, open-loop, rich	1.63	99.2	1.82
Arctic Cat 4-stroke snowmobile	2.3-3.3	20-140	2.4-6.5

Ford van emissions are based on a simulated snowcoach driving cycle, while Arctic Cat data are from steady-state operation on a chassis dynamometer. If one assumes that the open-loop Ford van emission value is close to real in-field operation, the snowcoach would appear to be the cleaner solution, given its ability to handle more passengers than a snowmobile. However, it should also be kept in mind:

- the estimated Ford van emission factor may be way off (it could be low)
- there are other types of snowcoaches in service that do not have the extremely clean Ford engine/catalyst package. Their emissions could be higher than the Ford's by an order of magnitude or more.
- as demonstrated by the Idaho sled, further significant reductions in snowmobile emissions could be achieved through the use of catalyst.

It is entirely possible that acceptable, low-emissions solutions can be developed for both snowcoaches and snowmobiles. This is one of the accomplishments of Lori Fussell and Bill Paddleford's SAE Clean Snowmobile Challenge.

Grams per mile snowmobile emissions data reported from chassis testing are limited in accuracy by the assumptions used to select engine speeds and loads to be representative of specific sled speeds. Ideally, one would use field measured rpm, torque, and mph data. Such data were not available for this program, so engine and sled speeds were obtained visually from the snowmobile's gauges while operated in the field.

For the four-mode chassis dynamometer cycle, mode one load is set based on the in-field observed maximum sled mph and engine rpm. Intermediate modes are scaled from the torque observed at mode one. While this approach seems reasonable, it is sensitive to the selected mode one speeds. It also assumes that the snowmobile's CVT follows the same speed and torque operation, prescribed by the 5-mode engine-cycle setpoints.

If it is to be further used, the chassis dynamometer procedure needs refinement. A better procedure should be developed to obtain field data to establish proper speed and load setpoints for the chassis dynamometer. A second question needing to be addressed is the value of using a steady-state test cycle. In the field, snowmobile operation is clearly transient. Some of the sensitivities and limitations of a steady-state cycle could be overcome by using some type of driving cycle. This could conceivably be run on either a chassis or an engine dynamometer. It should be designed so that it is simple and economical to run. Work to develop a next-generation procedure should be considered.

An attempt has been made to compare emissions from currently-available 4-stroke snowmobiles and a Ford V-10-based snowcoach. Unfortunately, many assumptions had to be made in estimation of a snowcoach emission factor. In view of the importance of that data, it is recommended that work be undertaken to develop better snowcoach emissions data based on in-field measurement. SwRI would be happy to discuss possible approaches for this.

V. ACKNOWLEDGMENTS

The authors would like to recognize the many people who contributed to this program. Special thanks goes out to Howard Haines of the Montana Department of Environmental Quality for his expertise and consultant efforts and Lori Fussell of the Institute of Science, Ecology, and the Environment for her continued dedication as organizer of the Clean Snowmobile Challenge. We would also like to thank Kevin Meyer and Joe Evers of Dynojet Research Inc. for their generosity and consultation on chassis dynamometer setup. We also appreciate Mark Foster and Bruce Cunningham of Yellowstone National Park, for providing critical technical information and snowmobile parts. Others deserving acknowledgment are the many SwRI employees that worked diligently to achieve accurate results, including Jim Carroll, Danny Estrada, Gale Harper, Tim Travis, and Sharon Tondre.

VI. REFERENCES

1. 2002 Arctic Cat Snowmobile Operator's Manual, Arctic Cat Inc., Thief River Falls, MN 56701, part no. 2256-397, 2001.
2. Wright, C.W., and White, J.J., "Development and Validation of a Snowmobile Engine Emission Test Procedure," SAE 982017, Milwaukee, Wisconsin, September 1998.
3. White, J.J., Carroll, J.N., Fussell, L.M., and Haines, H.E., "Low-Emission Snowmobiles-The 2001 SAE Clean Snowmobile Challenge," SAE 2001-01-1832/4253.
4. "Regression Modeling of Oxyfuel Effects on Ambient CO Concentrations," Systems Applications International, Inc., January 8, 1997.
5. Fanick, R.E., Schubert, P.F., Russell, B.J., and Freerks, R.L., "Comparison of Emission Characteristic of Conventional, Hydrotreated, and Fischer-Tropsch Diesel Fuels in a Heavy-Duty Diesel Engine," SAE 2001-01-3519.
6. White, J.J., Carroll, J.N., and Haines, H.E., "Emissions from Snowmobiles Using Bio-Based Fuels and Lubricants," SAE 972108, Yokohama, Japan, October 1997.
7. White, J.J., Carroll, J.N., Lourenco, J.G., and Downing-Iaali, A., "Baseline and Controlled Exhaust Emissions from Off-Highway Vehicle Engines," SAE 931541, Pisa, Italy, December 1993.
8. EPA Federal Register 40 CFR Part 89, 90, 91, "Control of Emissions From Nonroad Large Spark Ignition Engines and Recreational Engines (Marine and Land-Based); Proposed Rule," October 5, 2001.
9. California Code of Regulations, "Emission Standards and Test Procedures-New Off-Highway Recreational Vehicles and Engines," Part I, September 1999.
10. White, J.J., and Carroll, J. N., "Emissions from Snowmobile Engines Using Bio-based Fuels and Lubricants," SwRI Final Report 7383, October 1998.
11. Fussell, L. M., Bishop, G.A., and Daily, J., "The SAE Clean Snowmobile Challenge 2000-Summary and Results," SAE 2000-01-2552, Milwaukee, WI, September 2000.
12. Lela, C.C., White, J.J., and Carroll, J.N., "Determination of Snowcoach Emissions Factor," SwRI Final Report 5053, December 2001.

APPENDIX A

BREAK-IN LOG SHEETS

TABLE A-1. ARCTIC CAT SNOWMOBILE BREAK-IN LOG SHEET

Date	Time Start, hh:mm	Time Stop, hh:mm	Duration, min	Throttle Position, %	Engine Speed, rpm	Vehicle Speed, mph	Begin Odometer, miles
5/14/02	8:00 AM	8:15 AM	15	0	Idle	0	6.2
	8:15 AM	9:10 AM	55	10	4400	24.5	6.2
	Vehicle off to check fluid levels						
	9:30 AM	10:00 AM	30	15	4800	34.6	29.7
	10:00 AM	10:05 AM	5	5	3900	13.9	47.6
	10:05 AM	10:30 AM	25	20	5000	35.6	49.3
	10:30 AM	10:37 AM	7	20	4700	27.5	65.3
	10:37 AM	10:40 AM	3	0	Idle (1200)	0	68.5
	10:40 AM	10:55 AM	15	20	4800	35.4	68.5
	10:55 AM	11:00 AM	5	20	4700	31.1	76.2
	11:00 AM	11:05 AM	5	20	4600	26.8	79.5
	11:05 AM	11:15 AM	10	25	5100	39.1	83.1
	11:15 AM	11:25 AM	10	25	4900	29.2	88.1
	11:25 AM	11:40 AM	15	25	5200	42.9	96.1
	11:40 AM	12:10 PM	30	25	5200	43.5	106.1
	12:10 PM	12:35 PM	25	25	5200	43.9	129.3
	12:35 PM	12:45 PM	10	0	Idle (1200)	0	148.2
	12:45 PM	1:07 PM	22	25	5200	39.7	148.2
	1:07 PM	1:30 PM	23	25	5000	33.3	166.4
	1:30 PM	2:00 PM	30	25	5200	41	181.4
	2:00 PM	2:10 PM	10	10	4100	19.9	203.6
	2:10 PM	2:30 PM	20	20	4500	19.8	206.4
	2:30 PM	2:32 PM	2	20	4800	31.6	214.3
	2:32 PM	2:47 PM	15	20	4800	33.5	215.6
	2:47 PM	3:30 PM	13	30	5400	45.7	228.2
	3:30 PM	4:05 PM	35	0	Idle (1200)	0	259.1
	4:05 PM	4:10 PM	25	20	4800	34.5	259.1
	4:10 PM	4:30 PM	20	25	5100	39.8	264.2
	4:30 PM	4:40 PM	10	28	5300	44.7	276.5
	4:40 PM	4:55 PM	15	28	5100	39.2	285.6
4:55 PM	5:30 PM	35	28	5300	45.4	297.9	
5:30 PM	5:55 PM	25	28	5200	42.4	324.4	

TABLE A-1 (CONT'D). ARCTIC CAT SNOWMOBILE BREAK-IN LOG SHEET

Date	Time Start, hh:mm	Time Stop, hh:mm	Duration, min	Throttle Position, %	Engine Speed, rpm	Vehicle Speed, mph	Begin Odometer, miles	
5/14/02	5:55 PM	6:55 PM	60	28	5300	45.4	343	
	6:55 PM	7:15 PM	20	28	5100	41.7	393.6	
	7:15 PM	7:45 PM	30	28	5300	45.7	407.4	
	7:45 PM	8:05 PM	20	28	5200	43.4	434.5	
	8:05 PM	8:20 PM	15	28	5300	45.6	447.8	
	8:20 PM	8:25 PM	5	0	Idle (1200)	0	459.4	
5/15/02	5:40 PM	5:55 PM	15	0	Idle (1200)	0	459.4	
	5:55 PM	6:10 PM	15	18	4700	25.8	460	
	6:10 PM	7:10 PM	60	25	5300	35.7	467.8	
	7:10 PM	7:17 PM	7	25	5400	48.4	511.4	
	Vehicle off-refueling							
	7:25 PM	7:28 PM	3	20	5200	44.1	517.4	
	7:28 PM	8:05 PM	37	28	5500	52	520.1	
	8:05 PM	8:48 PM	43	28	5500	50.7	551.6	
	8:48 PM	8:59 PM	11	28	5400	49.3	591.2	
	Engine off @ 8:59 PM							600.1
	Break-in completed. Oil change							

TABLE A-2. POLARIS ENGINE BREAK-IN LOG SHEET

Date	Time Start, hh:mm	Time Stop, hh:mm	Duration, min	Engine Load, ft-lbs	Engine Speed, rpm	
5/16/02	9:20 AM	9:39 AM	19	0	Idle (1300)	
	10:00 AM	10:10 AM	10	0	Idle (1300)	
	10:10 AM	10:20 AM	10	10	2400	
	10:20 AM	10:44 AM	24	20	3800	
	10:44 AM	10:50 AM	6	0	Idle (1300)	
5/17/02	3:05 PM	3:27 PM	12	20	38	
5/19/02	8:23 AM	8:33 AM	10	0	Idle (1400)	
	8:33 AM	8:47 AM	14	16.7	4200	
	8:47 AM	8:55 AM	8	17	4800	
	8:55 AM	9:11 AM	16	16	5100	
	9:11 AM	9:20 AM	9	17	4760	
	9:20 AM	9:50 AM	30	0	Idle	
	9:50 AM	10:10 AM	20	18	5000	
	10:10 AM	10:20 AM	10	24	5300	
	Engine off, refuel and oil check					
	10:28 AM	10:48 AM	20	22.2	4560	
	10:48 AM	11:09 AM	21	25.6	5175	
	11:09 AM	11:23 AM	14	24	4500	
	11:23 AM	11:37 AM	14	25	4330	
	11:37 AM	11:59 AM	22	27	5400	
	11:59 AM	12:06 PM	7	0	Idle (1500)	
	12:06 PM	12:25 PM	19	21.25	5400	
	12:25 PM	12:47 PM	22	23.4	5580	
	Engine off for refueling					
	12:47 PM	12:50 PM	3	0	Idle (1500)	
	1:14 PM	1:32 PM	17	0	Idle (1500)	
	1:32 PM	1:47 PM	15	23.6	4800	
	1:47 PM	2:03 PM	16	23	5458	
	2:03 PM	2:19 PM	16	36.5	5464	
	2:19 PM	2:32 PM	13	20	4900	
	2:36 PM	2:53 PM	17	20.65	5220	
	2:53 PM	3:13 PM	20	36.8	5520	
	3:13 PM	3:34 PM	21	8	5525	
3:34 PM	3:54 PM	20	0	Idle (1500)		

TABLE A-2 (CONT'D). POLARIS ENGINE BREAK-IN LOG SHEET

Date	Time Start, hh:mm	Time Stop, hh:mm	Duration, min	Engine Load, ft-lbs	Engine Speed, RPM
5/19/02	Engine off for refueling				
	4:08 PM	4:16 PM	8	0	Idle (1500)
	4:16 PM	4:30 PM	14	22.6	4980
	4:30 PM	4:45 PM	15	41.4	5280
	4:45 PM	5:00 PM	15	19.8	5700
	5:00 PM	5:10 PM	10	14.5	5690
	5:10 PM	5:23 PM	13	25	5100
	5:23 PM	5:30 PM	7	0	Idle (1500)
	Engine off for refueling				
	5:35 PM	5:56 PM	21	29.3	5290
	5:56 PM	6:07 PM	11	19.75	4980
	6:07 PM	6:23 PM	16	16.5	5400
	6:23 PM	6:40 PM	17	20.51	5870
	6:40 PM	7:00 PM	20	0	Idle (1500)
	Break-In completed, Oil Change				

APPENDIX B

TEST VEHICLE OPERATION INFORMATION

Snowmobiles were operated in the field at various steady speeds, and a log was made of vehicle versus engine speeds, as read from the snowmobile's gauges. These data were used to setup snowmobile operation on the chassis dynamometer.

TABLE B-1. ARCTIC CAT 4-STROKE TOURING SNOWMOBILE OPERATING PARAMETERS

Vehicle Speed, mph	Engine Speed, rpm
15	4200
25	5000
35	5500
45	5700
50 (max)	6000

TABLE B-2. POLARIS 4-STROKE FRONTIER SNOWMOBILE OPERATING PARAMETERS

Vehicle Speed, mph	Engine Speed, rpm
15	4500
25	5000
35	5700
45	5900
50 (max)	6000

TABLE B-3. KETTERING UNIVERSITY SNOWMOBILE OPERATING PARAMETERS

Vehicle Speed, mph	Engine Speed, rpm
Idle	1500
15	3900
25	4650
35	5500
45	6000
65 (max)	6200

TABLE B-4. UNIVERSITY OF IDAHO SNOWMOBILE OPERATING PARAMETERS

Vehicle Speed, mph	Engine Speed, rpm
Idle	950
15	4900
25	5200
35	5300 ^a
45	6200
65 (max)	7500

^a SwRI and the University of Idaho deemed this engine speed unrealistic for the vehicle speed mentioned. It was agreed, for setup on the chassis dynamometer, that 5700 rpm was a more realistic engine speed for this vehicle speed.

APPENDIX C

MODAL AND COMPOSITE EMISSIONS DATA

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.7 L (40 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N:
 Arctic Cat 4-stroke

Test No.: AC-Sled-1
 Date: 05/20/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 02 4-Stroke Touring

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.00
 Chassis EEE 5-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,500	0.0	0.0	300	6,250	108.0	22.22	74.0	7.8	29.29	0.912	1.000	0.979	1.007
2	6,100	0.0	0.0	300	6,000	82.0	15.29	75.1	7.6	29.28	0.908	1.000	0.980	1.009
3	5,600	0.0	0.0	300	5,500	51.0	9.62	75.4	7.7	29.28	0.909	1.000	0.982	1.009
4	5,000	0.0	0.0	300	5,000	45.0	6.95	75.4	7.5	29.27	0.903	1.000	0.983	1.009
5	4,250	0.0	0.0	300	4,200	41.0	4.99	74.6	7.3	29.27	0.899	1.000	0.984	1.008

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	26.8	163.98	6,943.0	120.9	2.50	20,528	1.000	--	--	--	--	--	--
2	18.3	115.14	2,332.1	276.9	0.91	17,965	1.000	--	--	--	--	--	--
3	8.8	79.87	1,277.6	172.5	0.93	11,572	1.000	--	--	--	--	--	--
4	5.9	60.09	445.8	159.6	1.10	9,100	1.000	--	--	--	--	--	--
5	3.1	45.55	431.4	78.7	1.01	6,353	1.000	--	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-Sled-1	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 05/20/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat 4-stroke	02 4-Stroke Touring	Chassis EEE 5-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	99.2 (29.29)	99.1 (29.28)	99.1 (29.28)	99.1 (29.27)
Dil. Air: Temp, °C (°F) / AH, g/kg	23.9 (75.0) / 9.0	23.9 (75.0) / 9.1	24.4 (76.0) / 8.8	25.0 (77.0) / 8.6
Engine Air Dew Pt., °C (°F)	9.9 (49.9)	9.6 (49.3)	9.7 (49.5)	9.3 (48.7)
Engine Air Temp, °C (°F)	23.3 (74.0)	23.9 (75.1)	24.1 (75.4)	24.1 (75.4)
Engine Air: RH,% / AH, g/kg	43 / 7.8	40 / 7.6	40 / 7.7	39 / 7.5
NOx Humidity C.F.	.912	.908	.909	.903
Dry-to-Wet C.F.	.979	.980	.982	.983
Time, seconds	300.1	300.1	300.2	300.1
Tot. Blower Rate, scmm (scfm)*	26.40 (1,000.4)	26.54 (1,005.7)	26.66 (1,010.4)	26.79 (1,015.2)
90mm Sample Rate, scmm (scfm)*	0.0573 (2.17)	0.0567 (2.15)	0.0564 (2.14)	0.0562 (2.13)
Total Volume, scm (scf)*	132.3 (5,015)	133.0 (5,041)	133.7 (5,066)	134.3 (5,088)
HC Sample Meter/Range/ppm	17.3/1,000/173.4	12.2/1,000/122.3	8.9/1,000/89.2	68.5/100/68.9
HC Bckgrd Meter/Range/ppm	0.7/1,000/7.0	0.6/1,000/6.0	0.9/1,000/9.0	8.6/100/8.8
CO Sample Meter/Range/ppm (Dry)	78.9/6,000/3,605.0	56.9/3,000/1,202.5	70.3/1,000/652.5	51.2/500/226.1
CO Bckgrd Meter/Range/ppm	0.0/6,000/0.0	0.0/3,000/0.0	0.0/1,000/0.0	0.0/500/0.0
CO2 Sample Meter/Range/% (Wet)	71.8/1/0.6999	63.8/1/0.6157	43.7/1/0.4117	35.3/1/0.3296
CO2 Bckgrd Meter/Range/%	4.9/1/0.0448	4.9/1/0.0448	5.0/1/0.0457	4.7/1/0.0430
NOx Sample Meter/Range/ppm (Wet)	40.7/100/41.0	93.5/100/93.6	57.8/100/57.9	53.5/100/53.7
NOx Bckgrd Meter/Range/ppm	0.3/100/0.3	0.5/100/0.5	0.3/100/0.3	0.2/100/0.2
Dilution Factor	12.55	17.99	27.66	37.36
HC Concentration, ppm	166.93	116.59	80.51	60.29
CO Concentration, ppm	3,500.75	1,169.69	637.82	221.54
CO2 Concentration, %	0.66	0.57	0.37	0.29
NOx Concentration, ppm	40.68	93.14	57.64	53.46
HC Mass, grams	13.67	9.60	6.66	5.01
CO Mass, grams	578.77	194.41	106.53	37.17
CO2 Mass, grams	1,711.23	1,497.56	964.99	758.59
NOx Mass, grams	10.08	23.08	14.38	13.31
Part. Mass, grams	0.209	0.076	0.078	0.092
Fuel, kg (lb)	0.840 (1.85)	0.578 (1.27)	0.364 (0.80)	0.263 (0.58)
KW-HR (hp-hr)	1.66 (2.23)	1.14 (1.53)	0.55 (0.74)	0.37 (0.49)
Filter Number	9199.0-4	9200.0-5	9201.0-6	9202.0-7
Weight Gain, mg	0.452	0.162	0.164	0.192
Sample Multiplier	0.462	0.469	0.474	0.478
Blower 1, scf	5,003.7	5,030.3	5,055.4	5,077.7
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.960	6.894	6.931	6.927
Gas Meter 2, scf	17.816	17.649	17.620	17.578

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-Sled-1	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 05/20/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat 4-stroke	02 4-Stroke Touring	Chassis EEE 5-mode

Mode Number	5
Barometer, kPa (in Hg)	99.1 (29.27)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 8.6
Engine Air Dew Pt., °C (°F)	8.9 (48.1)
Engine Air Temp, °C (°F)	23.7 (74.6)
Engine Air: RH,% / AH, g/kg	39 / 7.3
NOx Humidity C.F.	.899
Dry-to-Wet C.F.	.984
Time, seconds	300.1
Tot. Blower Rate, scmm (scfm)*	26.83 (1,016.8)
90mm Sample Rate, scmm (scfm)*	0.0561 (2.13)
Total Volume, scm (scf)*	134.5 (5,096)
HC Sample Meter/Range/ppm	53.0/100/53.6
HC Bckgrd Meter/Range/ppm	7.9/100/8.1
CO Sample Meter/Range/ppm (Dry)	49.6/500/218.1
CO Bckgrd Meter/Range/ppm	0.0/500/0.0
CO2 Sample Meter/Range/% (Wet)	26.3/1/0.2436
CO2 Bckgrd Meter/Range/%	4.8/1/0.0439
NOx Sample Meter/Range/ppm (Wet)	26.4/100/26.7
NOx Bckgrd Meter/Range/ppm	0.3/100/0.3
Dilution Factor	49.56
HC Concentration, ppm	45.62
CO Concentration, ppm	214.04
CO2 Concentration, %	0.20
NOx Concentration, ppm	26.43
HC Mass, grams	3.80
CO Mass, grams	35.96
CO2 Mass, grams	529.62
NOx Mass, grams	6.56
Part. Mass, grams	0.084
Fuel, kg (lb)	0.189 (0.42)
KW-HR (hp-hr)	0.20 (0.26)
Filter Number	9203.0-8
Weight Gain, mg	0.175
Sample Multiplier	0.479
Blower 1, scf	5,085.6
Blower 2, scf	0.0
Gas Meter 1, scf	6.987
Gas Meter 2, scf	17.627

* scf at 68°F and scm at 0 °C

02 Arctic Cat 4-Stroke Touring
 Test No: AC-Sled-1
 Date: 5/20/02

Emissions vs. MPH, Chassis Dynamometer Test
 Engine: 4-Stroke
 Displacement: 660cc
 Rated Speed: 6000 RPM

Fuel: EEE (Gasoline)
 SwRI

Test No.	Speed	Mode Duration	Distance	Power	C-B Fuel	Emissions					Brake-Specific Emissions				
						HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
						grams/hr					grams/hp-hr				
	mph	sec	miles	hp	lb/hr										
AC-Sled-1	50	300.1	4.17	26.8	22.22	163.98	6,943.00	120.90	2.50	20,528	6.12	259.07	4.51	0.09	765.97
	45	300.1	3.75	18.3	15.29	115.14	2,332.10	276.90	0.91	17,965	6.29	127.44	15.13	0.05	981.69
	35	300.2	2.92	8.8	9.62	79.87	1,277.60	172.50	0.93	11,572	9.08	145.18	19.60	0.11	1315.00
	25	300.1	2.08	5.9	6.95	60.09	445.80	159.60	1.10	9,100	10.18	75.56	27.05	0.19	1542.37
	15	300.1	1.25	3.1	4.99	45.55	431.40	78.70	1.01	6,353	14.69	139.16	25.39	0.33	2049.35

Emissions				
HC	CO	NOx	Part.	CO ₂
grams/mile				
3.28	138.86	2.42	0.05	410.56
2.56	51.82	6.15	0.02	399.22
2.28	36.50	4.93	0.03	330.63
2.40	17.83	6.38	0.04	364.00
3.04	28.76	5.25	0.07	423.53

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.7 L (40 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N:
 Arctic Cat 4-stroke

Test No.: AC-SLED-2
 Date: 05/20/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 02 4-Stroke Touring

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.00
 Chassis EEE 4-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	160.0	180	6,000	160.0	22.09	80.2	8.3	29.23	0.927	1.000	0.979	1.018
2	5,100	51.0	81.6	300	5,100	82.0	9.38	77.4	7.7	29.23	0.910	1.000	0.982	1.014
3	4,500	33.0	52.8	300	4,500	53.0	5.87	76.4	7.5	29.23	0.904	1.000	0.983	1.012
4	1,000	0.0	0.0	300	1,000	0.0	0.87	75.4	7.2	29.22	0.896	1.000	0.985	1.011

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	29.5	161.20	6,762.5	118.6	2.05	20,640	1.000	5.46	229.26	4.02	0.07	699.75	1
2	10.6	80.36	1,083.6	179.5	1.22	11,528	1.000	7.59	102.42	16.97	0.12	1,089.59	2
3	5.0	55.95	410.6	115.9	0.94	7,622	1.000	11.24	82.48	23.28	0.19	1,531.07	3
4	0.0	12.16	159.9	0.3	0.40	963	1.000	--	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-SLED-2	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 05/20/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat 4-stroke	02 4-Stroke Touring	Chassis EEE 4-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	99.0 (29.23)	99.0 (29.23)	99.0 (29.23)	98.9 (29.22)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 8.8	24.4 (76.0) / 8.8	24.4 (76.0) / 8.8	24.4 (76.0) / 8.8
Engine Air Dew Pt., °C (°F)	10.9 (51.6)	9.7 (49.5)	9.3 (48.7)	8.7 (47.7)
Engine Air Temp, °C (°F)	26.8 (80.2)	25.2 (77.4)	24.7 (76.4)	24.1 (75.4)
Engine Air: RH,% / AH, g/kg	37 / 8.3	38 / 7.7	38 / 7.5	37 / 7.2
NOx Humidity C.F.	.927	.910	.904	.896
Dry-to-Wet C.F.	.979	.982	.983	.985
Time, seconds	179.9	300.1	300.1	300.2
Tot. Blower Rate, scmm (scfm)*	26.58 (1,007.2)	26.73 (1,013.0)	26.74 (1,013.2)	26.77 (1,014.5)
90mm Sample Rate, scmm (scfm)*	0.0581 (2.20)	0.0563 (2.13)	0.0562 (2.13)	0.0570 (2.16)
Total Volume, scm (scf)*	79.9 (3,026)	134.0 (5,078)	134.0 (5,078)	134.2 (5,087)
HC Sample Meter/Range/ppm	17.0/1,000/170.4	88.3/100/88.4	63.3/100/63.8	18.6/100/19.0
HC Bckgrd Meter/Range/ppm	0.8/1,000/8.0	7.7/100/7.9	7.5/100/7.7	6.7/100/6.9
CO Sample Meter/Range/ppm (Dry)	77.7/6,000/3,484.4	61.5/1,000/551.9	47.7/500/208.6	82.5/100/81.1
CO Bckgrd Meter/Range/ppm	0.0/6,000/0.0	0.0/1,000/0.0	0.0/500/0.0	0.3/100/0.3
CO2 Sample Meter/Range/% (Wet)	71.8/1/0.6999	43.2/1/0.4068	30.5/1/0.2835	8.0/1/0.0732
CO2 Bckgrd Meter/Range/%	5.0/1/0.0457	4.7/1/0.0430	4.7/1/0.0430	4.7/1/0.0430
NOx Sample Meter/Range/ppm (Wet)	39.1/100/39.4	59.8/100/59.9	38.7/100/39.0	0.2/100/0.2
NOx Bckgrd Meter/Range/ppm	0.4/100/0.4	0.1/100/0.1	0.1/100/0.1	0.1/100/0.1
Dilution Factor	12.69	28.53	43.18	161.28
HC Concentration, ppm	162.99	80.79	56.24	12.20
CO Concentration, ppm	3,386.75	539.59	204.44	79.51
CO2 Concentration, %	0.66	0.37	0.24	0.03
NOx Concentration, ppm	39.00	59.82	38.88	0.11
HC Mass, grams	8.06	6.70	4.66	1.01
CO Mass, grams	337.94	90.33	34.23	13.34
CO2 Mass, grams	1,031.43	961.02	635.39	80.30
NOx Mass, grams	5.93	14.97	9.66	0.03
Part. Mass, grams	0.103	0.102	0.079	0.033
Fuel, kg (lb)	0.501 (1.10)	0.354 (0.78)	0.222 (0.49)	0.033 (0.07)
KW-HR (hp-hr)	1.10 (1.47)	0.66 (0.88)	0.31 (0.42)	0.00 (0.00)
Filter Number	9204.0-9	9205.0-10	9206.0-11	9207.0-12
Weight Gain, mg	0.224	0.214	0.165	0.070
Sample Multiplier	0.458	0.476	0.477	0.471
Blower 1, scf	3,019.8	5,066.9	5,067.7	5,076.1
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	4.265	6.999	6.947	6.942
Gas Meter 2, scf	10.870	17.669	17.592	17.748

* scf at 68°F and scm at 0°C

02 Arctic Cat 4-Stroke Touring
 Test No: AC-Sled-2
 Date: 5/20/02

4-Mode Chassis Dynamometer Test
 Engine: 4-Stroke
 Displacement: 660cc
 Rated Speed: 6000 RPM

Fuel: EEE (Gasoline)
 SwRI

Test No.	% of Rated Engine Speed	% of Maximum Torque	Engine Speed	Vehicle Speed	Mode Duration	Distance	Modal Weight Factor	Power	C-B Fuel	Mass Emissions					Unweighted Brake-Specific Modal Emissions				
			RPM	mph	sec	miles	%	hp	lb/hr	HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
												grams/hr					grams/hp-hr		
AC-Sled-2	100	100	6000	36	179.9	1.80	18	29.5	22.09	161.20	6,762.50	118.60	2.05	20,640	5.46	229.24	4.02	0.07	699.66
	85	51	5100	26	300.1	2.17	39	10.6	9.38	80.36	1,083.60	179.50	1.22	11,528	7.58	102.23	16.93	0.12	1087.55
	75	33	4500	19	300.1	1.58	36	5	5.87	55.95	410.60	115.90	0.94	7,622	11.19	82.12	23.18	0.19	1524.40
	Idle	0	1000	0	300.2	0.00	7	0	0.87	12.16	159.90	0.30	0.40	963	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Hourly Composite Emissions		
HC	grams/hr	81.35
CO	grams/hr	1798.86
NOx	grams/hr	133.10
Part.	grams/hr	1.21
CO ₂	grams/hr	11022

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	7.23
BSCO	grams/hp-hr	159.98
BSNOx	grams/hp-hr	11.84
BSPart.	grams/hp-hr	0.11
BSCO ₂	grams/hp-hr	980
BSFC	lb/hp-hr	0.872

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.7 L (40 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N:
 Arctic Cat

Test No.: AC-EEE-1
 Date: 06/06/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 02 4-Stroke Touring

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.17
 EEE #1 w/HC spec.

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	36.0	301	5,994	36.0	21.68	81.0	5.4	29.07	0.851	1.000	0.977	1.020
2	5,100	51.0	18.3	300	5,102	18.4	9.98	70.3	4.4	29.06	0.828	1.000	0.979	1.005
3	4,500	33.0	11.9	299	4,502	11.9	6.62	68.3	4.0	29.06	0.820	1.000	0.981	1.002
4	3,900	19.0	6.8	300	3,899	6.7	4.33	68.3	4.0	29.05	0.819	1.000	0.982	1.002
5	1,000	0.0	0.0	300	1,043	0.0	0.89	68.9	4.1	29.04	0.821	1.000	0.983	1.003

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	41.1	149.66	4,861.2	143.1	1.40	23,061	1.000	3.64	118.34	3.48	0.03	561.39	1
2	17.9	77.15	587.1	159.7	0.79	13,188	1.000	4.32	32.88	8.95	0.04	738.56	2
3	10.2	53.03	181.7	125.5	0.82	9,073	1.000	5.20	17.82	12.31	0.08	889.87	3
4	4.9	35.81	129.5	60.3	0.74	5,905	1.000	7.24	26.18	12.19	0.15	1,194.00	4
5	0.0	12.60	118.8	0.5	0.40	1,046	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.7 L (40 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N:
 Arctic Cat

Test No.: AC-EEE-1
 Date: 06/06/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 02 4-Stroke Touring

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.17
 EEE #1 w/HC spec.

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.4 (29.07)	98.4 (29.06)	98.4 (29.06)	98.4 (29.05)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.0	25.6 (78.0) / 10.5	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0
Engine Air Dew Pt., °C (°F)	4.6 (40.2)	1.6 (34.9)	0.4 (32.8)	0.3 (32.6)
Engine Air Temp, °C (°F)	27.2 (81.0)	21.3 (70.3)	20.2 (68.3)	20.2 (68.3)
Engine Air: RH,% / AH, g/kg	23 / 5.4	27 / 4.4	27 / 4.0	26 / 4.0
NOx Humidity C.F.	.851	.828	.820	.819
Dry-to-Wet C.F.	.977	.979	.981	.982
Time, seconds	300.6	300.2	299.4	299.9
Tot. Blower Rate, scmm (scfm)*	26.15 (990.8)	26.28 (995.7)	26.44 (1,001.8)	26.60 (1,007.9)
90mm Sample Rate, scmm (scfm)*	0.0572 (2.17)	0.0567 (2.15)	0.0568 (2.15)	0.0568 (2.15)
Total Volume, scm (scf)*	131.3 (4,975)	131.8 (4,992)	132.2 (5,010)	133.2 (5,048)
HC Sample Meter/Range/ppm	15.9/1,000/159.4	84.8/100/85.0	59.4/100/59.9	41.2/100/41.8
HC Bckgrd Meter/Range/ppm	0.6/1,000/6.0	6.1/100/6.3	6.0/100/6.2	5.6/100/5.8
CO Sample Meter/Range/ppm (Dry)	66.8/6,000/2,553.9	66.3/500/305.1	94.6/100/93.8	68.2/100/66.5
CO Bckgrd Meter/Range/ppm	0.0/6,000/0.0	0.0/500/0.0	0.2/100/0.2	0.4/100/0.4
CO2 Sample Meter/Range/% (Wet)	79.9/1/0.7867	49.3/1/0.4674	35.7/1/0.3335	24.9/1/0.2303
CO2 Bckgrd Meter/Range/%	4.7/1/0.0430	4.8/1/0.0439	4.8/1/0.0439	4.7/1/0.0430
NOx Sample Meter/Range/ppm (Wet)	52.0/100/52.2	59.4/100/59.5	46.7/100/46.9	22.1/100/22.4
NOx Bckgrd Meter/Range/ppm	0.1/100/0.1	0.0/100/0.0	0.0/100/0.0	0.0/100/0.0
Dilution Factor	12.76	26.50	38.43	55.60
HC Concentration, ppm	153.82	78.92	53.91	36.18
CO Concentration, ppm	2,474.70	297.44	91.51	64.80
CO2 Concentration, %	0.75	0.43	0.29	0.19
NOx Concentration, ppm	52.08	59.52	46.92	22.42
HC Mass, grams	12.50	6.43	4.41	2.98
CO Mass, grams	405.91	48.96	15.11	10.79
CO2 Mass, grams	1,925.58	1,099.72	754.61	491.93
NOx Mass, grams	11.95	13.32	10.44	5.02
Part. Mass, grams	0.117	0.065	0.069	0.061
Fuel, kg (lb)	0.821 (1.81)	0.377 (0.83)	0.250 (0.55)	0.163 (0.36)
KW-HR (hp-hr)	2.56 (3.43)	1.11 (1.49)	0.63 (0.85)	0.31 (0.41)
Filter Number	8951.0-68	8952.0-69	8953.0-70	8954.0-71
Weight Gain, mg	0.255	0.141	0.147	0.131
Sample Multiplier	0.458	0.465	0.466	0.469
Blower 1, scf	4,964.1	4,981.7	4,998.8	5,037.7
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.804	6.768	6.713	6.749
Gas Meter 2, scf	17.655	17.516	17.460	17.511

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.7 L (40 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N:
 Arctic Cat

Test No.: AC-EEE-1
 Date: 06/06/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 02 4-Stroke Touring

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.17
 EEE #1 w/HC spec.

Mode Number	5
Barometer, kPa (in Hg)	98.3 (29.04)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.1
Engine Air Dew Pt., °C (°F)	0.6 (33.0)
Engine Air Temp, °C (°F)	20.5 (68.9)
Engine Air: RH,% / AH, g/kg	26 / 4.1
NOx Humidity C.F.	.821
Dry-to-Wet C.F.	.983
Time, seconds	300.1
Tot. Blower Rate, scmm (scfm)*	26.64 (1,009.7)
90mm Sample Rate, scmm (scfm)*	0.0570 (2.16)
Total Volume, scm (scf)*	133.6 (5,061)
HC Sample Meter/Range/ppm	17.4/100/17.8
HC Bckgrd Meter/Range/ppm	5.0/100/5.1
CO Sample Meter/Range/ppm (Dry)	62.3/100/60.6
CO Bckgrd Meter/Range/ppm	0.2/100/0.2
CO2 Sample Meter/Range/% (Wet)	8.3/1/0.0760
CO2 Bckgrd Meter/Range/%	4.7/1/0.0430
NOx Sample Meter/Range/ppm (Wet)	0.7/25/0.2
NOx Bckgrd Meter/Range/ppm	0.0/25/0.0
Dilution Factor	160.02
HC Concentration, ppm	12.71
CO Concentration, ppm	59.37
CO2 Concentration, %	0.03
NOx Concentration, ppm	0.18
HC Mass, grams	1.05
CO Mass, grams	9.91
CO2 Mass, grams	87.23
NOx Mass, grams	0.04
Part. Mass, grams	0.034
Fuel, kg (lb)	0.033 (0.07)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	8955.0-72
Weight Gain, mg	0.072
Sample Multiplier	0.468
Blower 1, scf	5,050.0
Blower 2, scf	0.0
Gas Meter 1, scf	6.739
Gas Meter 2, scf	17.550
* scf at 68°F and scm at 0 °C	

02 Arctic Cat 4-Stroke Touring
 Test No: AC-EEE-1
 Date: 6/6/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 660cc
 Rated Speed: 6000 RPM

Fuel: EEE (Gasoline)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					grams/hr					hp	grams/hr				
AC-EEE-1	1	12	41.1	21.68	149.66	4861.20	143.10	1.40	23,061	4.9	17.96	583.34	17.17	0.17	2,767
	2	27	17.9	9.98	77.15	587.10	159.70	0.79	13,188	4.8	20.83	158.52	43.12	0.21	3,561
	3	25	10.2	6.62	53.03	181.70	125.50	0.82	9,073	2.6	13.26	45.43	31.38	0.21	2,268
	4	31	4.9	4.33	35.81	129.50	60.30	0.74	5,905	1.5	11.10	40.15	18.69	0.23	1,831
	5	5	0	0.89	12.60	118.80	0.50	0.47	1,046	0.0	0.63	5.94	0.03	0.02	52
Totals										13.8	63.78	833.37	110.38	0.84	10,479

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
AC-EEE-1	1	3.64	118.28	3.48	0.03	561.09
	2	4.31	32.80	8.92	0.04	736.76
	3	5.20	17.81	12.30	0.08	889.51
	4	7.31	26.43	12.31	0.15	1205.10
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	4.61
BSCO	grams/hp-hr	60.24
BSNOx	grams/hp-hr	7.98
BSPart.	grams/hp-hr	0.06
BSCO ₂	grams/hp-hr	757
BSFC	lb/hp-hr	0.603

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-EEE-2	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/06/2002 Time:	HCR: 1.850 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	EEE #2

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	36.2	300	6,000	36.2	21.69	78.2	5.7	29.03	0.857	1.000	0.977	1.018
2	5,100	51.0	18.4	300	5,104	18.5	10.18	73.0	4.7	29.02	0.835	1.000	0.980	1.010
3	4,500	33.0	11.9	300	4,506	12.0	6.63	72.2	4.6	29.00	0.832	1.000	0.981	1.010
4	3,900	19.0	6.9	298	3,893	6.6	4.23	71.7	4.6	28.99	0.832	1.000	0.983	1.009
5	1,000	0.0	0.0	300	1,024	0.0	0.84	70.8	4.4	28.99	0.828	1.000	0.984	1.008

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	41.3	152.04	4,864.8	139.6	1.42	23,074	1.000	3.68	117.76	3.38	0.03	558.51	1
2	18.0	78.88	588.6	165.4	1.09	13,463	1.000	4.38	32.71	9.19	0.06	748.19	2
3	10.3	53.02	168.7	117.5	1.00	9,099	1.000	5.17	16.44	11.45	0.10	887.13	3
4	4.9	35.21	96.7	61.0	0.71	5,827	1.000	7.19	19.76	12.45	0.14	1,190.64	4
5	0.0	11.50	103.6	0.5	0.27	1,010	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-EEE-2	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/06/2002 Time:	HCR: 1.850 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	EEE #2

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.3 (29.03)	98.3 (29.02)	98.2 (29.01)	98.2 (28.99)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 9.6	23.9 (75.0) / 9.8	24.4 (76.0) / 10.3	24.4 (76.0) / 9.6
Engine Air Dew Pt., °C (°F)	5.2 (41.3)	2.6 (36.6)	2.2 (35.9)	2.1 (35.8)
Engine Air Temp, °C (°F)	25.7 (78.2)	22.8 (73.0)	22.3 (72.2)	22.1 (71.7)
Engine Air: RH,% / AH, g/kg	27 / 5.7	26 / 4.7	26 / 4.6	27 / 4.6
NOx Humidity C.F.	.857	.835	.832	.832
Dry-to-Wet C.F.	.977	.980	.981	.983
Time, seconds	300.2	300.1	300.1	297.9
Tot. Blower Rate, scmm (scfm)*	26.24 (994.2)	26.27 (995.4)	26.34 (998.2)	26.37 (999.4)
90mm Sample Rate, scmm (scfm)*	0.0568 (2.15)	0.0566 (2.15)	0.0570 (2.16)	0.0569 (2.16)
Total Volume, scm (scf)*	131.6 (4,985)	131.7 (4,989)	132.0 (5,004)	131.2 (4,973)
HC Sample Meter/Range/ppm	16.0/1,000/160.4	86.7/100/86.8	59.7/100/60.2	41.1/100/41.7
HC Bckgrd Meter/Range/ppm	0.5/1,000/5.0	6.2/100/6.4	6.1/100/6.3	5.8/100/6.0
CO Sample Meter/Range/ppm (Dry)	66.7/6,000/2,546.6	66.5/500/306.2	88.6/100/87.4	51.6/100/50.0
CO Bckgrd Meter/Range/ppm	0.0/6,000/0.0	0.0/500/0.0	0.2/100/0.2	0.2/100/0.2
CO2 Sample Meter/Range/% (Wet)	79.7/1/0.7846	50.1/1/0.4755	35.7/1/0.3335	24.8/1/0.2294
CO2 Bckgrd Meter/Range/%	4.7/1/0.0430	4.7/1/0.0430	4.6/1/0.0420	4.7/1/0.0430
NOx Sample Meter/Range/ppm (Wet)	50.1/100/50.3	61.0/100/61.1	43.2/100/43.4	22.2/100/22.5
NOx Bckgrd Meter/Range/ppm	0.0/100/0.0	0.0/100/0.0	0.0/100/0.0	0.0/100/0.0
Dilution Factor	12.79	26.07	38.50	56.19
HC Concentration, ppm	155.74	80.70	54.09	35.88
CO Concentration, ppm	2,468.17	298.29	85.23	48.81
CO2 Concentration, %	0.74	0.43	0.29	0.19
NOx Concentration, ppm	50.29	61.11	43.44	22.52
HC Mass, grams	12.68	6.58	4.42	2.91
CO Mass, grams	405.67	49.07	14.06	8.00
CO2 Mass, grams	1,924.08	1,122.29	758.50	482.21
NOx Mass, grams	11.64	13.79	9.79	5.04
Part. Mass, grams	0.118	0.091	0.083	0.059
Fuel, kg (lb)	0.820 (1.81)	0.385 (0.85)	0.251 (0.55)	0.159 (0.35)
KW-HR (hp-hr)	2.57 (3.45)	1.12 (1.50)	0.64 (0.86)	0.30 (0.41)
Filter Number	8956.0-73	8957.0-74	8958.0-75	8959.0-76
Weight Gain, mg	0.256	0.196	0.179	0.126
Sample Multiplier	0.463	0.465	0.464	0.464
Blower 1, scf	4,974.3	4,978.7	4,992.8	4,962.0
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.683	6.674	6.644	6.617
Gas Meter 2, scf	17.457	17.409	17.439	17.325

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-EEE-2	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/06/2002 Time:	HCR: 1.850 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	EEE #2

Mode Number	5
Barometer, kPa (in Hg)	98.1 (28.99)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 9.6
Engine Air Dew Pt., °C (°F)	1.6 (34.9)
Engine Air Temp, °C (°F)	21.6 (70.8)
Engine Air: RH,% / AH, g/kg	27 / 4.4
NOx Humidity C.F.	.828
Dry-to-Wet C.F.	.984
Time, seconds	300.2
Tot. Blower Rate, scmm (scfm)*	26.43 (1,001.7)
90mm Sample Rate, scmm (scfm)*	0.0571 (2.16)
Total Volume, scm (scf)*	132.5 (5,022)
HC Sample Meter/Range/ppm	17.2/100/17.6
HC Bckgrd Meter/Range/ppm	5.8/100/6.0
CO Sample Meter/Range/ppm (Dry)	54.8/100/53.2
CO Bckgrd Meter/Range/ppm	0.1/100/0.1
CO2 Sample Meter/Range/% (Wet)	8.1/1/0.0741
CO2 Bckgrd Meter/Range/%	4.6/1/0.0420
NOx Sample Meter/Range/ppm (Wet)	0.8/25/0.2
NOx Bckgrd Meter/Range/ppm	0.1/25/0.0
Dilution Factor	165.25
HC Concentration, ppm	11.70
CO Concentration, ppm	52.15
CO2 Concentration, %	0.03
NOx Concentration, ppm	0.17
HC Mass, grams	0.96
CO Mass, grams	8.64
CO2 Mass, grams	84.19
NOx Mass, grams	0.04
Part. Mass, grams	0.022
Fuel, kg (lb)	0.032 (0.07)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	8960.0-77
Weight Gain, mg	0.048
Sample Multiplier	0.464
Blower 1, scf	5,011.7
Blower 2, scf	0.0
Gas Meter 1, scf	6.684
Gas Meter 2, scf	17.512

* scf at 68°F and scm at 0 °C

02 Arctic Cat 4-Stroke Touring
 Test No: AC-EEE-2
 Date: 6/6/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 660cc
 Rated Speed: 6000 RPM

Fuel: EEE (Gasoline)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					grams/hr					hp	grams/hr				
AC-EEE-2	1	12	41.3	21.69	152.04	4864.80	139.60	1.42	23,074	5.0	18.24	583.78	16.75	0.17	2,769
	2	27	18	10.18	78.88	588.60	165.40	1.09	13,463	4.9	21.30	158.92	44.66	0.29	3,635
	3	25	10.3	6.63	53.02	168.70	117.50	1.00	9,099	2.6	13.26	42.18	29.38	0.25	2,275
	4	31	4.9	4.23	35.21	96.70	61.00	0.71	5,827	1.5	10.92	29.98	18.91	0.22	1,806
	5	5	0	0.84	11.50	103.60	0.50	0.40	1,010	0.0	0.58	5.18	0.03	0.02	51
Totals										13.9	64.29	820.03	109.72	0.95	10,536

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
AC-EEE-2	1	3.68	117.79	3.38	0.03	558.69
	2	4.38	32.70	9.19	0.06	747.94
	3	5.15	16.38	11.41	0.10	883.40
	4	7.19	19.73	12.45	0.14	1189.18
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	4.62
BSCO	grams/hp-hr	58.95
BSNOx	grams/hp-hr	7.89
BSPart.	grams/hp-hr	0.07
BSCO ₂	grams/hp-hr	757
BSFC	lb/hp-hr	0.601

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/11/2002 Time:	HCR: 1.940 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	E10 #1 w/HC Spec.

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	34.2	300	5,999	34.2	22.48	83.4	6.8	28.99	0.886	1.000	0.978	1.028
2	5,100	51.0	17.4	300	5,100	17.7	10.92	80.6	6.3	28.98	0.872	1.000	0.979	1.024
3	4,500	33.0	11.3	300	4,503	11.3	6.81	73.7	4.8	28.97	0.838	1.000	0.981	1.013
4	3,900	19.0	6.5	299	3,895	6.2	4.42	74.7	5.1	28.97	0.843	1.000	0.983	1.015
5	1,000	0.0	0.0	300	1,057	0.0	0.89	73.7	4.8	28.97	0.838	1.000	0.983	1.013

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	39.1	148.09	4,209.6	240.4	1.55	23,464	1.000	3.79	107.74	6.15	0.04	600.53	1
2	17.2	83.96	507.9	255.2	1.02	13,778	1.000	4.88	29.52	14.83	0.06	800.65	2
3	9.7	55.26	168.7	145.3	0.89	8,815	1.000	5.72	17.45	15.03	0.09	911.95	3
4	4.6	34.33	56.7	58.5	0.69	5,804	1.000	7.47	12.34	12.74	0.15	1,262.83	4
5	0.0	11.27	71.0	0.5	0.33	1,067	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/11/2002 Time:	HCR: 1.940 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	E10 #1 w/HC Spec.

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.2 (28.99)	98.1 (28.98)	98.1 (28.97)	98.1 (28.97)
Dil. Air: Temp, °C (°F) / AH, g/kg	23.9 (75.0) / 9.2	24.4 (76.0) / 10.3	24.4 (76.0) / 9.6	25.0 (77.0) / 9.4
Engine Air Dew Pt., °C (°F)	7.8 (46.0)	6.6 (43.9)	2.9 (37.3)	3.6 (38.4)
Engine Air Temp, °C (°F)	28.6 (83.4)	27.0 (80.6)	23.2 (73.7)	23.7 (74.7)
Engine Air: RH,% / AH, g/kg	27 / 6.8	27 / 6.3	27 / 4.8	27 / 5.1
NOx Humidity C.F.	.886	.872	.838	.843
Dry-to-Wet C.F.	.978	.979	.981	.983
Time, seconds	300.0	300.0	300.2	299.2
Tot. Blower Rate, scmm (scfm)*	25.88 (980.8)	26.13 (990.3)	26.27 (995.6)	26.36 (998.7)
90mm Sample Rate, scmm (scfm)*	0.0595 (2.25)	0.0572 (2.17)	0.0570 (2.16)	0.0575 (2.18)
Total Volume, scm (scf)*	129.7 (4,915)	131.0 (4,963)	131.7 (4,992)	131.7 (4,991)
HC Sample Meter/Range/ppm	15.7/1,000/157.4	90.7/100/90.8	63.2/100/63.7	40.3/100/40.9
HC Bckgrd Meter/Range/ppm	0.5/1,000/5.0	5.1/100/5.2	7.5/100/7.7	6.1/100/6.3
CO Sample Meter/Range/ppm (Dry)	82.5/3,000/2,235.0	59.0/500/266.1	89.1/100/88.0	30.8/100/29.7
CO Bckgrd Meter/Range/ppm	0.0/3,000/0.0	0.1/500/0.4	0.6/100/0.6	0.5/100/0.5
CO2 Sample Meter/Range/% (Wet)	82.2/1/0.8116	51.5/1/0.4896	35.3/1/0.3296	25.2/1/0.2332
CO2 Bckgrd Meter/Range/%	5.2/1/0.0475	4.9/1/0.0448	5.1/1/0.0466	5.2/1/0.0475
NOx Sample Meter/Range/ppm (Wet)	85.1/100/85.2	90.8/100/90.9	53.5/100/53.7	86.5/25/21.6
NOx Bckgrd Meter/Range/ppm	0.2/100/0.2	0.2/100/0.2	0.2/100/0.2	1.2/25/0.3
Dilution Factor	12.83	25.53	38.87	55.75
HC Concentration, ppm	152.73	85.77	56.16	34.77
CO Concentration, ppm	2,164.67	258.71	85.46	28.64
CO2 Concentration, %	0.77	0.45	0.28	0.19
NOx Concentration, ppm	84.97	90.70	53.46	21.35
HC Mass, grams	12.34	7.00	4.61	2.85
CO Mass, grams	350.80	42.33	14.07	4.71
CO2 Mass, grams	1,955.31	1,148.13	735.04	482.40
NOx Mass, grams	20.04	21.27	12.11	4.87
Part. Mass, grams	0.130	0.085	0.074	0.057
Fuel, kg (lb)	0.850 (1.87)	0.413 (0.91)	0.258 (0.57)	0.166 (0.37)
KW-HR (hp-hr)	2.43 (3.26)	1.07 (1.43)	0.60 (0.81)	0.28 (0.38)
Filter Number	9015.0-93	9016.0-94	9017.0-95	9018.0-96
Weight Gain, mg	0.297	0.185	0.160	0.125
Sample Multiplier	0.436	0.458	0.462	0.460
Blower 1, scf	4,904.1	4,951.7	4,981.2	4,980.2
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.878	6.766	6.753	6.664
Gas Meter 2, scf	18.151	17.609	17.558	17.522

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/11/2002 Time:	HCR: 1.940 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	E10 #1 w/HC Spec.

Mode Number	5
Barometer, kPa (in Hg)	98.1 (28.97)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.1
Engine Air Dew Pt., °C (°F)	2.9 (37.2)
Engine Air Temp, °C (°F)	23.2 (73.7)
Engine Air: RH,% / AH, g/kg	26 / 4.8
NOx Humidity C.F.	.838
Dry-to-Wet C.F.	.983
Time, seconds	300.1
Tot. Blower Rate, scmm (scfm)*	26.43 (1,001.6)
90mm Sample Rate, scmm (scfm)*	0.0573 (2.17)
Total Volume, scm (scf)*	132.5 (5,020)
HC Sample Meter/Range/ppm	16.8/100/17.2
HC Bckgrd Meter/Range/ppm	5.7/100/5.9
CO Sample Meter/Range/ppm (Dry)	38.3/100/37.0
CO Bckgrd Meter/Range/ppm	0.6/100/0.6
CO2 Sample Meter/Range/% (Wet)	8.7/1/0.0796
CO2 Bckgrd Meter/Range/%	5.0/1/0.0457
NOx Sample Meter/Range/ppm (Wet)	1.5/25/0.4
NOx Bckgrd Meter/Range/ppm	0.8/25/0.2
Dilution Factor	157.64
HC Concentration, ppm	11.39
CO Concentration, ppm	35.77
CO2 Concentration, %	0.03
NOx Concentration, ppm	0.18
HC Mass, grams	0.94
CO Mass, grams	5.92
CO2 Mass, grams	88.93
NOx Mass, grams	0.04
Part. Mass, grams	0.028
Fuel, kg (lb)	0.034 (0.07)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	9026.0-97
Weight Gain, mg	0.060
Sample Multiplier	0.462
Blower 1, scf	5,009.6
Blower 2, scf	0.0
Gas Meter 1, scf	6.747
Gas Meter 2, scf	17.604

* scf at 68°F and scm at 0 °C

02 Arctic Cat 4-Stroke Touring
 Test No: AC-GHOL-1
 Date: 6/11/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 660cc
 Rated Speed: 6000 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					grams/hr					hp	grams/hr				
AC-GHOL-1	1	12	39.1	22.48	148.09	4209.60	240.40	1.55	23,464	4.7	17.77	505.15	28.85	0.19	2,816
	2	27	17.2	10.92	83.96	507.90	255.20	1.02	13,778	4.6	22.67	137.13	68.90	0.28	3,720
	3	25	9.7	6.81	55.26	168.70	145.30	0.89	8,815	2.4	13.82	42.18	36.33	0.22	2,204
	4	31	4.6	4.42	34.33	56.70	58.50	0.69	5,804	1.4	10.64	17.58	18.14	0.21	1,799
	5	5	0	0.89	11.27	71.00	0.50	0.33	1,067	0.0	0.56	3.55	0.03	0.02	53
Totals										13.2	65.46	705.59	152.24	0.91	10,592

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
AC-GHOL-1	1	3.79	107.66	6.15	0.04	600.10
	2	4.88	29.53	14.84	0.06	801.05
	3	5.70	17.39	14.98	0.09	908.76
	4	7.46	12.33	12.72	0.15	1261.74
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	4.96
BSCO	grams/hp-hr	53.51
BSNOx	grams/hp-hr	11.54
BSPart.	grams/hp-hr	0.07
BSCO ₂	grams/hp-hr	803
BSFC	lb/hp-hr	0.665

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/10/2002 Time:	HCR: 1.940 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	Gasohol (E10) #2

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	32.8	300	6,000	32.8	22.00	79.6	6.0	28.98	0.865	1.000	0.975	1.022
2	5,100	51.0	16.7	300	5,105	16.8	10.45	72.6	4.7	28.98	0.835	1.000	0.980	1.011
3	4,500	33.0	10.8	300	4,499	10.9	6.61	73.0	4.7	28.98	0.835	1.000	0.980	1.012
4	3,900	19.0	6.2	300	3,899	6.2	4.46	72.3	4.6	28.98	0.832	1.000	0.982	1.011
5	1,000	0.0	0.0	300	1,029	0.0	0.81	69.4	4.2	28.98	0.824	1.000	0.984	1.006

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	37.5	143.77	3,911.0	235.8	1.49	23,283	1.000	3.84	104.39	6.29	0.04	621.47	1
2	16.4	76.04	317.7	251.7	1.09	13,458	1.000	4.65	19.41	15.38	0.07	822.27	2
3	9.3	49.08	69.7	141.6	0.96	8,716	1.000	5.26	7.47	15.18	0.10	934.25	3
4	4.6	31.67	40.5	57.3	0.88	5,897	1.000	6.87	8.80	12.43	0.19	1,279.77	4
5	0.0	9.82	62.6	0.4	0.58	978	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/10/2002 Time:	HCR: 1.940 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	Gasohol (E10) #2

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.1 (28.98)	98.1 (28.98)	98.1 (28.98)	98.1 (28.98)
Dil. Air: Temp, °C (°F) / AH, g/kg	23.9 (75.0) / 10.6	24.4 (76.0) / 9.6	24.4 (76.0) / 10.3	24.4 (76.0) / 9.6
Engine Air Dew Pt., °C (°F)	5.9 (42.6)	2.6 (36.6)	2.6 (36.6)	2.2 (35.9)
Engine Air Temp, °C (°F)	26.4 (79.6)	22.6 (72.6)	22.8 (73.0)	22.4 (72.3)
Engine Air: RH,% / AH, g/kg	27 / 6.0	27 / 4.7	26 / 4.7	26 / 4.6
NOx Humidity C.F.	.865	.835	.835	.832
Dry-to-Wet C.F.	.975	.980	.980	.982
Time, seconds	299.9	299.8	300.2	300.0
Tot. Blower Rate, scmm (scfm)*	26.00 (985.2)	26.11 (989.6)	26.23 (994.1)	26.28 (995.7)
90mm Sample Rate, scmm (scfm)*	0.0570 (2.16)	0.0579 (2.19)	0.0574 (2.18)	0.0579 (2.19)
Total Volume, scm (scf)*	130.2 (4,935)	130.8 (4,956)	131.5 (4,985)	131.7 (4,990)
HC Sample Meter/Range/ppm	15.1/1,000/151.3	83.9/100/84.1	55.8/100/56.4	38.0/100/38.6
HC Bckgrd Meter/Range/ppm	0.4/1,000/4.0	6.4/100/6.6	6.4/100/6.6	6.4/100/6.6
CO Sample Meter/Range/ppm (Dry)	79.2/3,000/2,071.9	70.7/250/166.1	37.5/100/36.2	21.9/100/21.1
CO Bckgrd Meter/Range/ppm	0.0/3,000/0.0	0.0/250/0.0	0.0/100/0.0	0.1/100/0.1
CO2 Sample Meter/Range/% (Wet)	81.2/1/0.8008	50.6/1/0.4805	35.3/1/0.3296	25.3/1/0.2341
CO2 Bckgrd Meter/Range/%	5.0/1/0.0457	5.0/1/0.0457	5.4/1/0.0494	4.9/1/0.0448
NOx Sample Meter/Range/ppm (Wet)	85.0/100/85.1	93.5/100/93.6	52.3/100/52.5	85.2/25/21.3
NOx Bckgrd Meter/Range/ppm	0.1/100/0.1	0.1/100/0.1	0.1/100/0.1	0.3/25/0.1
Dilution Factor	13.18	26.51	39.53	55.80
HC Concentration, ppm	147.63	77.74	49.95	32.18
CO Concentration, ppm	2,002.35	161.92	35.35	20.54
CO2 Concentration, %	0.76	0.44	0.28	0.19
NOx Concentration, ppm	84.97	93.53	52.37	21.23
HC Mass, grams	11.98	6.33	4.09	2.64
CO Mass, grams	325.81	26.46	5.81	3.38
CO2 Mass, grams	1,939.59	1,120.75	726.85	491.43
NOx Mass, grams	19.64	20.96	11.81	4.77
Part. Mass, grams	0.124	0.091	0.080	0.073
Fuel, kg (lb)	0.831 (1.83)	0.395 (0.87)	0.250 (0.55)	0.169 (0.37)
KW-HR (hp-hr)	2.33 (3.12)	1.02 (1.36)	0.58 (0.78)	0.29 (0.38)
Filter Number	9001.0-85	9010.0-86	9011.0-87	9034.0-88
Weight Gain, mg	0.271	0.201	0.175	0.161
Sample Multiplier	0.457	0.452	0.458	0.455
Blower 1, scf	4,924.4	4,944.6	4,973.7	4,978.6
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.755	6.666	6.653	6.641
Gas Meter 2, scf	17.547	17.626	17.545	17.602

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: AC-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-2	Date: 06/10/2002 Time:	HCR: 1.940 FID Resp: 1.17
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Arctic Cat	02 4-Stroke Touring	Gasohol (E10) #2

Mode Number	5
Barometer, kPa (in Hg)	98.1 (28.98)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 9.6
Engine Air Dew Pt., °C (°F)	1.0 (33.8)
Engine Air Temp, °C (°F)	20.8 (69.4)
Engine Air: RH,% / AH, g/kg	27 / 4.2
NOx Humidity C.F.	.824
Dry-to-Wet C.F.	.984
Time, seconds	300.0
Tot. Blower Rate, scmm (scfm)*	26.33 (997.9)
90mm Sample Rate, scmm (scfm)*	0.0578 (2.19)
Total Volume, scm (scf)*	132.0 (5,000)
HC Sample Meter/Range/ppm	15.5/100/15.9
HC Bckgrd Meter/Range/ppm	5.8/100/6.0
CO Sample Meter/Range/ppm (Dry)	33.4/100/32.2
CO Bckgrd Meter/Range/ppm	0.0/100/0.0
CO2 Sample Meter/Range/% (Wet)	8.3/1/0.0760
CO2 Bckgrd Meter/Range/%	4.9/1/0.0448
NOx Sample Meter/Range/ppm (Wet)	1.1/25/0.3
NOx Bckgrd Meter/Range/ppm	0.5/25/0.1
Dilution Factor	165.85
HC Concentration, ppm	9.96
CO Concentration, ppm	31.65
CO2 Concentration, %	0.03
NOx Concentration, ppm	0.15
HC Mass, grams	0.82
CO Mass, grams	5.22
CO2 Mass, grams	81.53
NOx Mass, grams	0.03
Part. Mass, grams	0.048
Fuel, kg (lb)	0.031 (0.07)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	9033.0-89
Weight Gain, mg	0.106
Sample Multiplier	0.457
Blower 1, scf	4,989.3
Blower 2, scf	0.0
Gas Meter 1, scf	6.669
Gas Meter 2, scf	17.617

* scf at 68°F and scm at 0 °C

02 Arctic Cat 4-Stroke Touring
 Test No: AC-GHOL-2
 Date: 6/10/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 660cc
 Rated Speed: 6000 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					grams/hr					hp	grams/hr				
AC-GHOL-2	1	12	37.5	22	143.77	3911.00	235.80	1.49	23,283	4.5	17.25	469.32	28.30	0.18	2,794
	2	27	16.4	10.45	76.04	317.70	251.70	1.09	13,458	4.4	20.53	85.78	67.96	0.29	3,634
	3	25	9.3	6.61	49.08	69.70	141.60	0.96	8,716	2.3	12.27	17.43	35.40	0.24	2,179
	4	31	4.6	4.46	31.67	40.50	57.30	0.88	5,897	1.4	9.82	12.56	17.76	0.27	1,828
	5	5	0	0.81	9.82	62.60	0.40	0.58	978	0.0	0.49	3.13	0.02	0.03	49
Totals										12.7	60.36	588.21	149.44	1.01	10,484

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
AC-GHOL-2	1	3.83	104.29	6.29	0.04	620.88
	2	4.64	19.37	15.35	0.07	820.61
	3	5.28	7.49	15.23	0.10	937.20
	4	6.88	8.80	12.46	0.19	1281.96
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	4.76
BSCO	grams/hp-hr	46.39
BSNOx	grams/hp-hr	11.79
BSPart.	grams/hp-hr	0.08
BSCO ₂	grams/hp-hr	827
BSFC	lb/hp-hr	0.673

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.8 L (48 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N: D002020201218
 Polaris 4-stroke

Test No.: P-EEE-1
 Date: 05/21/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 2002 Frontier

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.00
 EEE Test #1

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	38.1	300	6,005	38.1	24.53	84.8	9.1	29.28	0.950	1.000	0.976	1.024
2	5,100	51.0	19.4	300	5,095	19.5	12.01	81.9	8.9	29.27	0.945	1.000	0.978	1.020
3	4,500	33.0	12.6	300	4,519	12.6	8.52	79.6	9.0	29.27	0.946	1.000	0.980	1.017
4	3,900	19.0	7.2	300	3,906	7.4	6.10	75.7	8.4	29.27	0.931	1.000	0.980	1.011
5	1,200	0.0	0.0	300	1,186	0.0	1.72	70.3	8.5	29.27	0.931	1.000	0.982	1.004

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	43.6	167.65	5,509.6	228.7	3.84	26,088	1.000	3.85	126.41	5.25	0.09	598.52	1
2	18.9	36.17	411.5	123.7	1.25	16,517	1.000	1.92	21.79	6.55	0.07	874.74	2
3	10.8	10.77	278.3	38.1	0.96	11,781	1.000	1.00	25.76	3.53	0.09	1,090.44	3
4	5.5	7.60	239.9	9.8	0.95	8,372	1.000	1.39	43.75	1.79	0.17	1,526.56	4
5	0.0	34.48	136.9	1.0	0.72	2,150	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: P-EEE-1	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/21/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	EEE Test #1

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	99.1 (29.28)	99.1 (29.27)	99.1 (29.27)	99.1 (29.27)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 10.2	24.4 (76.0) / 10.2	24.4 (76.0) / 10.2	25.0 (77.0) / 10.7
Engine Air Dew Pt., °C (°F)	12.3 (54.1)	11.9 (53.5)	12.1 (53.7)	11.1 (52.0)
Engine Air Temp, °C (°F)	29.3 (84.8)	27.7 (81.9)	26.4 (79.6)	24.3 (75.7)
Engine Air: RH,% / AH, g/kg	35 / 9.1	38 / 8.9	41 / 9.0	44 / 8.4
NOx Humidity C.F.	.950	.945	.946	.931
Dry-to-Wet C.F.	.976	.978	.980	.980
Time, seconds	299.9	299.9	299.9	300.0
Tot. Blower Rate, scmm (scfm)*	26.35 (998.4)	26.60 (1,008.0)	26.77 (1,014.4)	26.86 (1,017.8)
90mm Sample Rate, scmm (scfm)*	0.0586 (2.22)	0.0561 (2.12)	0.0559 (2.12)	0.0561 (2.12)
Total Volume, scm (scf)*	132.0 (5,002)	133.2 (5,049)	134.1 (5,081)	134.6 (5,100)
HC Sample Meter/Range/ppm	17.7/1,000/177.4	41.8/100/42.4	15.6/100/16.0	12.2/100/12.5
HC Bckgrd Meter/Range/ppm	0.7/1,000/7.0	6.0/100/6.2	5.2/100/5.3	4.9/100/5.0
CO Sample Meter/Range/ppm (Dry)	93.7/3,000/2,880.6	26.8/1,000/211.8	61.7/250/143.2	53.5/250/122.8
CO Bckgrd Meter/Range/ppm	0.0/3,000/0.0	0.0/1,000/0.0	0.6/250/1.3	0.5/250/1.1
CO2 Sample Meter/Range/% (Wet)	88.8/1/0.8837	59.7/1/0.5732	44.6/1/0.4206	33.3/1/0.3104
CO2 Bckgrd Meter/Range/%	5.4/1/0.0494	5.4/1/0.0494	5.4/1/0.0494	5.2/1/0.0475
NOx Sample Meter/Range/ppm (Wet)	74.5/100/74.6	40.3/100/40.6	51.2/25/12.8	20.2/25/5.1
NOx Bckgrd Meter/Range/ppm	0.6/100/0.6	0.7/100/0.7	2.6/25/0.7	1.9/100/2.0
Dilution Factor	11.36	22.41	30.72	41.40
HC Concentration, ppm	171.00	36.54	10.81	7.60
CO Concentration, ppm	2,783.32	205.95	138.37	118.91
CO2 Concentration, %	0.84	0.53	0.37	0.26
NOx Concentration, ppm	73.99	39.88	12.19	3.18
HC Mass, grams	13.97	3.01	0.90	0.63
CO Mass, grams	458.98	34.28	23.18	19.99
CO2 Mass, grams	2,173.24	1,375.97	981.39	697.64
NOx Mass, grams	19.05	10.30	3.18	0.82
Part. Mass, grams	0.320	0.104	0.080	0.079
Fuel, kg (lb)	0.927 (2.04)	0.454 (1.00)	0.322 (0.71)	0.231 (0.51)
KW-HR (hp-hr)	2.71 (3.63)	1.17 (1.57)	0.67 (0.90)	0.34 (0.46)
Filter Number	9208.0-13	8661.0-14	8662.0-15	8663.0-16
Weight Gain, mg	0.710	0.219	0.167	0.165
Sample Multiplier	0.451	0.475	0.480	0.480
Blower 1, scf	4,990.6	5,038.4	5,070.3	5,089.0
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	7.075	6.962	6.987	6.996
Gas Meter 2, scf	18.168	17.583	17.578	17.616

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: P-EEE-1	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/21/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	EEE Test #1

Mode Number	5
Barometer, kPa (in Hg)	99.1 (29.27)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.7
Engine Air Dew Pt., °C (°F)	11.2 (52.1)
Engine Air Temp, °C (°F)	21.3 (70.3)
Engine Air: RH,% / AH, g/kg	52 / 8.5
NOx Humidity C.F.	.931
Dry-to-Wet C.F.	.982
Time, seconds	300.2
Tot. Blower Rate, scmm (scfm)*	26.92 (1,020.0)
90mm Sample Rate, scmm (scfm)*	0.0562 (2.13)
Total Volume, scm (scf)*	135.0 (5,114)
HC Sample Meter/Range/ppm	39.7/100/40.3
HC Bckgrd Meter/Range/ppm	5.8/100/6.0
CO Sample Meter/Range/ppm (Dry)	72.0/100/70.4
CO Bckgrd Meter/Range/ppm	1.4/100/1.3
CO2 Sample Meter/Range/% (Wet)	12.6/1/0.1156
CO2 Bckgrd Meter/Range/%	5.3/1/0.0484
NOx Sample Meter/Range/ppm (Wet)	3.2/25/0.8
NOx Bckgrd Meter/Range/ppm	2.0/25/0.5
Dilution Factor	105.90
HC Concentration, ppm	34.43
CO Concentration, ppm	67.70
CO2 Concentration, %	0.07
NOx Concentration, ppm	0.31
HC Mass, grams	2.88
CO Mass, grams	11.41
CO2 Mass, grams	179.27
NOx Mass, grams	0.08
Part. Mass, grams	0.060
Fuel, kg (lb)	0.065 (0.14)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	8664.0-17
Weight Gain, mg	0.125
Sample Multiplier	0.480
Blower 1, scf	5,103.6
Blower 2, scf	0.0
Gas Meter 1, scf	6.983
Gas Meter 2, scf	17.642

* scf at 68°F and scm at 0 °C

Polaris Engine
 02 Polaris 4-Stroke Frontier
 Test No: P-EEE-1
 Date: 5/21/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 784cc
 Rated Speed: 6000 RPM

Fuel: EEE (Gasoline)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					grams/hr					hp	grams/hr				
P-EEE-1	1	12	43.6	24.53	167.65	5509.60	228.70	3.84	26,088	5.2	20.12	661.15	27.44	0.46	3,131
	2	27	18.9	12.01	36.17	411.50	123.70	1.25	16,517	5.1	9.77	111.11	33.40	0.34	4,460
	3	25	10.8	8.52	10.77	278.30	38.10	0.96	11,781	2.7	2.69	69.58	9.53	0.24	2,945
	4	31	5.5	6.1	7.60	239.90	9.80	0.95	8,372	1.7	2.36	74.37	3.04	0.29	2,595
	5	5	0	1.72	34.48	136.90	1.00	0.72	2,150	0.0	1.72	6.85	0.05	0.04	108
Totals										14.7	36.66	923.05	73.46	1.37	13,238

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
P-EEE-1	1	3.85	126.37	5.25	0.09	598.35
	2	1.91	21.77	6.54	0.07	873.92
	3	1.00	25.77	3.53	0.09	1090.83
	4	1.38	43.62	1.78	0.17	1522.18
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	2.49
BSCO	grams/hp-hr	62.62
BSNOx	grams/hp-hr	4.98
BSPart.	grams/hp-hr	0.09
BSCO ₂	grams/hp-hr	898
BSFC	lb/hp-hr	0.698

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI
 Engine Desc.: 0.8 L (48 CID) I-2
 Engine Cycle: Otto-Cycle
 Engine S/N: D002020201218
 Polaris 4-stroke

Test No.: P-EEE-2
 Date: 05/03/2002 Time:
 Program SSDIL: 2.28-C
 Cell: 13 Bag Cart: 2
 2002 Frontier

GASOLINE EEE, EM-4378-F
 HCR: 1.850 FID Resp: 1.00
 EEE Test #2

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	38.8	300	5,993	38.8	23.98	78.5	10.1	29.27	0.980	1.000	0.975	1.017
2	5,100	51.0	19.8	300	5,108	19.9	11.62	79.1	9.7	29.23	0.969	1.000	0.979	1.019
3	4,500	33.0	12.8	300	4,509	12.7	8.63	77.5	9.2	29.26	0.952	1.000	0.980	1.015
4	3,900	19.0	7.4	300	3,886	7.4	5.94	75.4	9.1	29.25	0.951	1.000	0.981	1.012
5	1,200	0.0	0.0	300	1,182	0.0	1.71	72.3	8.3	29.25	0.927	1.000	0.983	1.007

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	44.3	156.95	4,729.8	291.0	2.61	26,557	1.000	3.54	106.69	6.56	0.06	599.06	1
2	19.4	27.48	347.2	109.6	1.15	16,081	1.000	1.42	17.93	5.66	0.06	830.32	2
3	9.5	12.36	281.6	41.4	0.94	11,924	1.000	1.30	29.58	4.35	0.10	1,252.35	3
4	5.5	6.94	233.1	13.6	0.79	8,154	1.000	1.27	42.71	2.49	0.15	1,493.95	4
5	0.0	36.05	138.2	1.1	0.35	2,131	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.:	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/03/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	EEE Test #2

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	99.1 (29.27)	99.0 (29.23)	99.1 (29.26)	99.1 (29.25)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 10.2	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0
Engine Air Dew Pt., °C (°F)	13.8 (56.8)	13.2 (55.8)	12.3 (54.2)	12.3 (54.1)
Engine Air Temp, °C (°F)	25.8 (78.5)	26.2 (79.1)	25.3 (77.5)	24.1 (75.4)
Engine Air: RH,% / AH, g/kg	47 / 10.1	45 / 9.7	44 / 9.2	48 / 9.1
NOx Humidity C.F.	.980	.969	.952	.951
Dry-to-Wet C.F.	.975	.979	.980	.981
Time, seconds	299.9	300.2	300.2	300.1
Tot. Blower Rate, scmm (scfm)*	26.38 (999.8)	26.63 (1,009.2)	26.64 (1,009.6)	26.69 (1,011.3)
90mm Sample Rate, scmm (scfm)*	0.0556 (2.11)	0.0564 (2.14)	0.0560 (2.12)	0.0559 (2.12)
Total Volume, scm (scf)*	132.2 (5,008)	133.5 (5,060)	133.6 (5,062)	133.8 (5,069)
HC Sample Meter/Range/ppm	16.5/1,000/165.4	33.7/100/34.3	18.1/100/18.5	12.2/100/12.5
HC Bckgrd Meter/Range/ppm	0.6/1,000/6.0	6.7/100/6.9	6.1/100/6.3	5.5/100/5.7
CO Sample Meter/Range/ppm (Dry)	86.9/3,000/2,470.5	41.7/500/179.4	62.1/250/144.2	51.9/250/118.9
CO Bckgrd Meter/Range/ppm	0.0/3,000/0.0	0.3/500/1.1	0.0/250/0.0	0.0/250/0.0
CO2 Sample Meter/Range/% (Wet)	90.0/1/0.8969	58.2/1/0.5578	44.7/1/0.4216	32.4/1/0.3017
CO2 Bckgrd Meter/Range/%	5.3/1/0.0484	5.3/1/0.0484	4.8/1/0.0439	4.8/1/0.0439
NOx Sample Meter/Range/ppm (Wet)	91.3/100/91.4	34.6/100/34.9	53.3/25/13.3	17.7/25/4.4
NOx Bckgrd Meter/Range/ppm	0.2/100/0.2	0.5/100/0.5	0.4/25/0.1	0.4/25/0.1
Dilution Factor	11.63	23.16	30.63	42.60
HC Concentration, ppm	159.88	27.73	12.46	6.99
CO Concentration, ppm	2,386.36	173.56	140.71	116.28
CO2 Concentration, %	0.85	0.51	0.38	0.26
NOx Concentration, ppm	91.21	34.41	13.23	4.33
HC Mass, grams	13.07	2.29	1.03	0.58
CO Mass, grams	394.02	28.95	23.49	19.43
CO2 Mass, grams	2,212.34	1,340.96	994.36	679.75
NOx Mass, grams	24.24	9.14	3.45	1.13
Part. Mass, grams	0.217	0.096	0.078	0.066
Fuel, kg (lb)	0.906 (2.00)	0.439 (0.97)	0.326 (0.72)	0.225 (0.50)
KW-HR (hp-hr)	2.75 (3.69)	1.20 (1.62)	0.59 (0.79)	0.34 (0.46)
Filter Number	8665.0-18	8670.0-23	8667.0-20	8668.0-21
Weight Gain, mg	0.457	0.203	0.164	0.138
Sample Multiplier	0.476	0.474	0.477	0.478
Blower 1, scf	4,997.4	5,049.5	5,051.6	5,058.4
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.984	6.987	6.963	6.998
Gas Meter 2, scf	17.511	17.670	17.574	17.593

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.:	GASOLINE EEE, EM-4378-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/03/2002 Time:	HCR: 1.850 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-C	
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	EEE Test #2

Mode Number	5
Barometer, kPa (in Hg)	99.0 (29.25)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.0
Engine Air Dew Pt., °C (°F)	10.9 (51.6)
Engine Air Temp, °C (°F)	22.4 (72.3)
Engine Air: RH,% / AH, g/kg	48 / 8.3
NOx Humidity C.F.	.927
Dry-to-Wet C.F.	.983
Time, seconds	299.9
Tot. Blower Rate, scmm (scfm)*	26.74 (1,013.4)
90mm Sample Rate, scmm (scfm)*	0.0556 (2.11)
Total Volume, scm (scf)*	133.9 (5,076)
HC Sample Meter/Range/ppm	41.2/100/41.8
HC Bckgrd Meter/Range/ppm	5.5/100/5.7
CO Sample Meter/Range/ppm (Dry)	71.8/100/70.2
CO Bckgrd Meter/Range/ppm	0.1/100/0.1
CO2 Sample Meter/Range/% (Wet)	12.2/1/0.1119
CO2 Bckgrd Meter/Range/%	4.9/1/0.0448
NOx Sample Meter/Range/ppm (Wet)	1.8/25/0.5
NOx Bckgrd Meter/Range/ppm	0.4/25/0.1
Dilution Factor	108.97
HC Concentration, ppm	36.23
CO Concentration, ppm	68.79
CO2 Concentration, %	0.07
NOx Concentration, ppm	0.35
HC Mass, grams	3.00
CO Mass, grams	11.51
CO2 Mass, grams	177.54
NOx Mass, grams	0.09
Part. Mass, grams	0.029
Fuel, kg (lb)	0.065 (0.14)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	8669.0-22
Weight Gain, mg	0.060
Sample Multiplier	0.482
Blower 1, scf	5,065.2
Blower 2, scf	0.0
Gas Meter 1, scf	6.978
Gas Meter 2, scf	17.505

* scf at 68°F and scm at 0 °C

Polaris Engine
 02 Polaris 4-Stroke Frontier
 Test No: P-EEE-2
 Date: 5/21/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 784cc
 Rated Speed: 6000 RPM

Fuel: EEE (Gasoline)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					grams/hr					hp	grams/hr				
P-EEE-2	1	12	44.3	23.98	156.95	4729.80	291.00	2.61	26,557	5.3	18.83	567.58	34.92	0.31	3,187
	2	27	19.4	11.62	27.48	347.20	109.60	1.15	16,081	5.2	7.42	93.74	29.59	0.31	4,342
	3	25	9.5	8.63	12.36	281.60	41.40	0.94	11,924	2.4	3.09	70.40	10.35	0.24	2,981
	4	31	5.5	5.94	6.94	233.10	13.60	0.79	8,154	1.7	2.15	72.26	4.22	0.24	2,528
	5	5	0	1.71	36.05	138.20	1.10	0.35	2,131	0.0	1.80	6.91	0.06	0.02	107
Totals										14.6	33.30	810.89	79.13	1.12	13,144

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
P-EEE-2	1	3.54	106.77	6.57	0.06	599.48
	2	1.42	17.90	5.65	0.06	828.92
	3	1.30	29.64	4.36	0.10	1255.16
	4	1.26	42.38	2.47	0.14	1482.55
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	2.28
BSCO	grams/hp-hr	55.41
BSNOx	grams/hp-hr	5.41
BSPart.	grams/hp-hr	0.08
BSCO ₂	grams/hp-hr	898
BSFC	lb/hp-hr	0.690

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: P-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/21/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	Gasohol Test #1

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	37.5	300	6,005	37.5	22.34	85.9	10.3	29.20	0.985	1.000	0.974	1.030
2	5,100	51.0	19.1	300	5,108	19.6	12.59	81.7	9.0	29.20	0.947	1.000	0.978	1.023
3	4,500	33.0	12.4	300	4,500	12.6	8.89	79.5	8.8	29.19	0.940	1.000	0.979	1.019
4	3,900	19.0	7.1	300	3,911	7.5	6.39	78.9	9.3	29.19	0.955	1.000	0.980	1.020
5	1,200	0.0	0.0	300	1,206	0.0	1.81	76.4	9.2	29.18	0.951	1.000	0.983	1.016

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	42.9	79.08	913.5	583.2	1.60	28,661	1.000	1.84	21.28	13.58	0.04	667.56	1
2	19.1	33.82	442.5	122.8	1.20	16,295	1.000	1.77	23.19	6.44	0.06	853.73	2
3	10.8	9.99	241.0	36.5	0.91	11,658	1.000	0.93	22.33	3.38	0.08	1,080.14	3
4	5.6	7.34	239.2	14.0	0.76	8,280	1.000	1.32	42.93	2.50	0.14	1,485.99	4
5	0.0	43.62	146.2	1.0	0.73	2,090	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: P-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/21/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	Gasohol Test #1

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.9 (29.20)	98.9 (29.20)	98.8 (29.19)	98.8 (29.19)
Dil. Air: Temp, °C (°F) / AH, g/kg	22.2 (72.0) / 10.5	22.8 (73.0) / 10.2	23.9 (75.0) / 10.5	23.3 (74.0) / 10.7
Engine Air Dew Pt., °C (°F)	14.0 (57.2)	12.1 (53.7)	11.7 (53.0)	12.5 (54.5)
Engine Air Temp, °C (°F)	29.9 (85.9)	27.6 (81.7)	26.4 (79.5)	26.1 (78.9)
Engine Air: RH,% / AH, g/kg	38 / 10.3	38 / 9.0	40 / 8.8	43 / 9.3
NOx Humidity C.F.	.985	.947	.940	.955
Dry-to-Wet C.F.	.974	.978	.979	.980
Time, seconds	300.1	299.9	300.2	299.8
Tot. Blower Rate, scmm (scfm)*	26.21 (993.1)	26.36 (998.9)	26.43 (1,001.6)	26.47 (1,003.2)
90mm Sample Rate, scmm (scfm)*	0.0556 (2.11)	0.0551 (2.09)	0.0551 (2.09)	0.0553 (2.10)
Total Volume, scm (scf)*	131.4 (4,978)	132.0 (5,003)	132.5 (5,022)	132.6 (5,023)
HC Sample Meter/Range/ppm	8.5/1,000/85.2	3.8/1,000/38.1	14.2/100/14.6	11.9/100/12.2
HC Bckgrd Meter/Range/ppm	0.5/1,000/5.0	0.4/1,000/4.0	4.5/100/4.6	4.8/100/4.9
CO Sample Meter/Range/ppm (Dry)	55.1/1,000/482.7	29.0/1,000/231.0	54.6/250/125.5	54.0/250/124.0
CO Bckgrd Meter/Range/ppm	0.0/1,000/0.0	0.1/1,000/0.7	0.4/250/0.9	0.3/250/0.7
CO2 Sample Meter/Range/% (Wet)	48.4/2/0.9708	28.0/2/0.5658	44.5/1/0.4196	33.4/1/0.3113
CO2 Bckgrd Meter/Range/%	2.4/2/0.0481	2.2/2/0.0441	5.2/1/0.0475	5.2/1/0.0475
NOx Sample Meter/Range/ppm (Wet)	73.4/250/183.5	39.8/100/40.1	49.8/25/12.5	19.8/25/5.0
NOx Bckgrd Meter/Range/ppm	0.2/250/0.5	0.2/100/0.2	2.4/25/0.6	2.0/25/0.5
Dilution Factor	13.06	22.62	30.91	41.26
HC Concentration, ppm	80.56	34.26	10.09	7.40
CO Concentration, ppm	464.00	223.47	121.39	120.29
CO2 Concentration, %	0.93	0.52	0.37	0.26
NOx Concentration, ppm	183.04	39.87	11.89	4.47
HC Mass, grams	6.59	2.82	0.83	0.61
CO Mass, grams	76.15	36.86	20.10	19.92
CO2 Mass, grams	2,389.18	1,357.43	972.12	689.50
NOx Mass, grams	48.62	10.23	3.04	1.16
Part. Mass, grams	0.133	0.100	0.076	0.063
Fuel, kg (lb)	0.845 (1.86)	0.476 (1.05)	0.336 (0.74)	0.241 (0.53)
KW-HR (hp-hr)	2.67 (3.58)	1.19 (1.59)	0.67 (0.90)	0.35 (0.46)
Filter Number	8671.0-24	8672.0-25	8673.0-26	8674.0-27
Weight Gain, mg	0.282	0.209	0.158	0.132
Sample Multiplier	0.472	0.479	0.480	0.480
Blower 1, scf	4,967.3	4,992.9	5,011.3	5,012.4
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	7.025	6.999	6.985	6.946
Gas Meter 2, scf	17.568	17.434	17.436	17.414

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.: P-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/21/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	Gasohol Test #1

Mode Number	5
Barometer, kPa (in Hg)	98.8 (29.18)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 10.2
Engine Air Dew Pt., °C (°F)	12.3 (54.1)
Engine Air Temp, °C (°F)	24.7 (76.4)
Engine Air: RH,% / AH, g/kg	46 / 9.2
NOx Humidity C.F.	.951
Dry-to-Wet C.F.	.983
Time, seconds	300.3
Tot. Blower Rate, scmm (scfm)*	26.58 (1,007.1)
90mm Sample Rate, scmm (scfm)*	0.0553 (2.10)
Total Volume, scm (scf)*	133.3 (5,051)
HC Sample Meter/Range/ppm	48.5/100/49.1
HC Bckgrd Meter/Range/ppm	5.2/100/5.3
CO Sample Meter/Range/ppm (Dry)	76.8/100/75.2
CO Bckgrd Meter/Range/ppm	0.6/100/0.6
CO2 Sample Meter/Range/% (Wet)	12.3/1/0.1128
CO2 Bckgrd Meter/Range/%	5.1/1/0.0466
NOx Sample Meter/Range/ppm (Wet)	2.6/25/0.7
NOx Bckgrd Meter/Range/ppm	1.4/25/0.4
Dilution Factor	107.06
HC Concentration, ppm	43.82
CO Concentration, ppm	73.24
CO2 Concentration, %	0.07
NOx Concentration, ppm	0.31
HC Mass, grams	3.64
CO Mass, grams	12.20
CO2 Mass, grams	174.37
NOx Mass, grams	0.08
Part. Mass, grams	0.061
Fuel, kg (lb)	0.068 (0.15)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	8675.0-28
Weight Gain, mg	0.126
Sample Multiplier	0.482
Blower 1, scf	5,040.4
Blower 2, scf	0.0
Gas Meter 1, scf	6.969
Gas Meter 2, scf	17.459

* scf at 68°F and scm at 0 °C

Polaris Engine
 02 Polaris 4-Stroke Frontier
 Test No: P-GHOL-1
 Date: 5/21/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 784cc
 Rated Speed: 6000 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					%	hp	lb/hr	grams/hr					hp	grams/hr	
P-GHOL-1	1	12	42.9	22.34	79.08	913.50	583.20	1.60	28,661	5.1	9.49	109.62	69.98	0.19	3,439
	2	27	19.1	12.59	33.82	442.50	122.80	1.20	16,295	5.2	9.13	119.48	33.16	0.32	4,400
	3	25	10.8	8.89	9.99	241.00	36.50	0.91	11,658	2.7	2.50	60.25	9.13	0.23	2,915
	4	31	5.6	6.39	7.34	239.20	14.00	0.76	8,280	1.7	2.28	74.15	4.34	0.24	2,567
	5	5	0	1.81	43.62	146.20	1.00	0.73	2,090	0.0	2.18	7.31	0.05	0.04	105
Totals										14.7	25.57	370.81	116.66	1.02	13,425

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
P-GHOL-1	1	1.84	21.29	13.59	0.04	668.09
	2	1.77	23.17	6.43	0.06	853.14
	3	0.93	22.31	3.38	0.08	1079.44
	4	1.31	42.71	2.50	0.14	1478.57
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	1.73
BSCO	grams/hp-hr	25.15
BSNOx	grams/hp-hr	7.91
BSPart.	grams/hp-hr	0.07
BSCO ₂	grams/hp-hr	911
BSFC	lb/hp-hr	0.704

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.:	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	Gasohol Test #2

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,000	100.0	39.5	300	6,000	39.5	23.62	75.0	8.5	29.15	0.932	1.000	0.976	1.015
2	5,100	51.0	20.2	300	5,109	20.2	12.73	76.4	8.0	29.14	0.917	1.000	0.978	1.016
3	4,500	33.0	13.0	300	4,496	13.1	9.06	74.6	7.9	29.14	0.914	1.000	0.980	1.013
4	3,900	19.0	7.5	300	3,906	7.8	6.52	73.2	8.0	29.14	0.917	1.000	0.981	1.012
5	1,200	0.0	0.0	300	1,192	0.0	1.76	73.6	8.2	29.14	0.923	1.000	0.983	1.012

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	45.2	115.90	2,315.0	450.1	1.60	28,074	1.000	2.57	51.26	9.97	0.04	621.59	1
2	19.7	32.50	344.2	126.0	1.28	16,636	1.000	1.65	17.51	6.41	0.07	846.35	2
3	11.2	8.33	257.8	36.3	0.86	11,866	1.000	0.74	23.03	3.25	0.08	1,059.88	3
4	5.8	5.87	224.1	14.0	0.85	8,482	1.000	1.01	38.58	2.41	0.15	1,459.92	4
5	0.0	41.88	146.3	1.0	0.86	2,039	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.:	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	Gasohol Test #2

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.7 (29.15)	98.7 (29.14)	98.7 (29.14)	98.7 (29.14)
Dil. Air: Temp, °C (°F) / AH, g/kg	24.4 (76.0) / 9.5	24.4 (76.0) / 10.2	23.9 (75.0) / 9.8	23.9 (75.0) / 9.8
Engine Air Dew Pt., °C (°F)	11.1 (52.0)	10.2 (50.3)	10.0 (50.0)	10.2 (50.3)
Engine Air Temp, °C (°F)	23.9 (75.0)	24.7 (76.4)	23.7 (74.6)	22.9 (73.2)
Engine Air: RH,% / AH, g/kg	45 / 8.5	40 / 8.0	42 / 7.9	44 / 8.0
NOx Humidity C.F.	.932	.917	.914	.917
Dry-to-Wet C.F.	.976	.978	.980	.981
Time, seconds	300.1	300.0	300.0	299.9
Tot. Blower Rate, scmm (scfm)*	26.06 (987.4)	26.18 (992.0)	26.18 (991.9)	26.21 (993.4)
90mm Sample Rate, scmm (scfm)*	0.0557 (2.11)	0.0552 (2.09)	0.0554 (2.10)	0.0551 (2.09)
Total Volume, scm (scf)*	130.6 (4,949)	131.2 (4,971)	131.2 (4,970)	131.3 (4,976)
HC Sample Meter/Range/ppm	12.4/1,000/124.3	38.6/100/39.2	14.3/100/14.7	11.2/100/11.5
HC Bckgrd Meter/Range/ppm	0.6/1,000/6.0	6.2/100/6.4	6.2/100/6.4	5.5/100/5.7
CO Sample Meter/Range/ppm (Dry)	57.6/3,000/1,224.8	76.1/250/180.1	58.4/250/134.9	51.1/250/116.9
CO Bckgrd Meter/Range/ppm	0.0/3,000/0.0	0.0/250/0.0	0.2/250/0.4	0.2/250/0.4
CO2 Sample Meter/Range/% (Wet)	47.5/2/0.9532	60.3/1/0.5794	45.1/1/0.4256	33.7/1/0.3142
CO2 Bckgrd Meter/Range/%	2.2/2/0.0441	4.7/1/0.0430	4.7/1/0.0430	4.5/1/0.0411
NOx Sample Meter/Range/ppm (Wet)	60.2/250/150.5	42.4/100/42.7	49.5/25/12.4	19.2/25/4.8
NOx Bckgrd Meter/Range/ppm	0.1/250/0.3	0.1/100/0.1	0.3/25/0.1	0.3/25/0.1
Dilution Factor	12.36	22.29	30.42	40.98
HC Concentration, ppm	118.76	33.15	8.50	5.98
CO Concentration, ppm	1,182.63	175.05	131.12	113.81
CO2 Concentration, %	0.91	0.54	0.38	0.27
NOx Concentration, ppm	150.26	42.56	12.30	4.72
HC Mass, grams	9.66	2.71	0.69	0.49
CO Mass, grams	192.98	28.69	21.49	18.67
CO2 Mass, grams	2,340.28	1,386.33	988.87	706.60
NOx Mass, grams	37.52	10.50	3.03	1.17
Part. Mass, grams	0.134	0.107	0.072	0.071
Fuel, kg (lb)	0.893 (1.97)	0.481 (1.06)	0.342 (0.75)	0.246 (0.54)
KW-HR (hp-hr)	2.81 (3.77)	1.22 (1.64)	0.70 (0.93)	0.36 (0.48)
Filter Number	8691.0-31	8692.0-32	8693.0-33	8694.0-34
Weight Gain, mg	0.285	0.225	0.152	0.148
Sample Multiplier	0.468	0.475	0.473	0.476
Blower 1, scf	4,938.7	4,960.1	4,959.7	4,965.2
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.981	6.929	6.849	6.915
Gas Meter 2, scf	17.546	17.392	17.351	17.360

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2002 4-stroke EFI	Test No.:	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (48 CID) I-2	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N: D002020201218	Cell: 13 Bag Cart: 2	
Polaris 4-stroke	2002 Frontier	Gasohol Test #2

Mode Number	5
Barometer, kPa (in Hg)	98.7 (29.14)
Dil. Air: Temp, °C (°F) / AH, g/kg	23.9 (75.0) / 9.8
Engine Air Dew Pt., °C (°F)	10.6 (51.0)
Engine Air Temp, °C (°F)	23.1 (73.6)
Engine Air: RH,% / AH, g/kg	45 / 8.2
NOx Humidity C.F.	.923
Dry-to-Wet C.F.	.983
Time, seconds	300.2
Tot. Blower Rate, scmm (scfm)*	26.30 (996.8)
90mm Sample Rate, scmm (scfm)*	0.0554 (2.10)
Total Volume, scm (scf)*	131.9 (4,998)
HC Sample Meter/Range/ppm	47.4/100/48.0
HC Bckgrd Meter/Range/ppm	5.4/100/5.6
CO Sample Meter/Range/ppm (Dry)	77.0/100/75.4
CO Bckgrd Meter/Range/ppm	0.0/100/0.0
CO2 Sample Meter/Range/% (Wet)	11.7/1/0.1073
CO2 Bckgrd Meter/Range/%	4.6/1/0.0420
NOx Sample Meter/Range/ppm (Wet)	1.6/25/0.4
NOx Bckgrd Meter/Range/ppm	0.3/25/0.1
Dilution Factor	112.07
HC Concentration, ppm	42.51
CO Concentration, ppm	74.03
CO2 Concentration, %	0.07
NOx Concentration, ppm	0.32
HC Mass, grams	3.49
CO Mass, grams	12.20
CO2 Mass, grams	170.05
NOx Mass, grams	0.08
Part. Mass, grams	0.072
Fuel, kg (lb)	0.067 (0.15)
KW-HR (hp-hr)	0.00 (0.00)
Filter Number	8695.0-35
Weight Gain, mg	0.151
Sample Multiplier	0.476
Blower 1, scf	4,987.1
Blower 2, scf	0.0
Gas Meter 1, scf	6.950
Gas Meter 2, scf	17.451

* scf at 68°F and scm at 0 °C

Polaris Engine
 02 Polaris 4-Stroke Frontier
 Test No: P-GHOL-2
 Date: 5/22/02

5-Mode Engine Dynamometer Test
 Engine: 4-Stroke
 Displacement: 784cc
 Rated Speed: 6000 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	Mode	Modal Weight Factor	Power	C-B Fuel	Unweighted Mass Emissions					Weighted Mass Emissions					
					HC	CO	NOx	Part.	CO ₂	BHP from Work	HC	CO	NOx	Part.	CO ₂
					%	hp	lb/hr	grams/hr					hp	grams/hr	
P-GHOL-2	1	12	45.2	23.62	115.90	2315.00	450.10	1.60	28,074	5.4	13.91	277.80	54.01	0.19	3,369
	2	27	19.7	12.73	32.50	344.20	126.00	1.28	16,636	5.3	8.78	92.93	34.02	0.35	4,492
	3	25	11.2	9.06	8.33	257.80	36.30	0.86	11,866	2.8	2.08	64.45	9.08	0.22	2,967
	4	31	5.8	6.52	5.87	224.10	14.00	0.85	8,482	1.8	1.82	69.47	4.34	0.26	2,629
	5	5	0	1.76	41.88	146.30	1.00	0.86	2,039	0.0	2.09	7.32	0.05	0.04	102
Totals										15.3	28.68	511.97	101.50	1.06	13,558

Brake-Specific Emissions Results

Test No.	Mode	Unweighted Modal Contribution				
		HC	CO	NOx	Part.	CO ₂
		grams/hp-hr				
P-GHOL-2	1	2.56	51.22	9.96	0.04	621.11
	2	1.65	17.47	6.40	0.06	844.47
	3	0.74	23.02	3.24	0.08	1059.46
	4	1.01	38.64	2.41	0.15	1462.41
	5	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	1.87
BSCO	grams/hp-hr	33.37
BSNOx	grams/hp-hr	6.62
BSPart.	grams/hp-hr	0.07
BSCO ₂	grams/hp-hr	884
BSFC	lb/hp-hr	0.694

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2001 4-stroke EFI	Test No.: UI-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (46 CID) I-3	Date: 05/23/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
BMW 4-stroke	2001 Arctic Cat ZR	Chassis E10 5-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	7,400	0.0	0.0	300	7,350	84.0	25.83	83.3	10.6	29.03	0.996	1.000	0.975	1.033
2	6,200	0.0	0.0	300	6,000	43.2	13.61	86.6	10.5	29.03	0.995	1.000	0.978	1.038
3	5,700	0.0	0.0	300	5,700	37.6	10.48	86.6	10.9	29.03	1.005	1.000	0.979	1.038
4	5,200	0.0	0.0	300	5,300	24.2	7.21	84.6	11.1	29.02	1.014	1.000	0.981	1.036
5	4,900	0.0	0.0	300	4,700	23.1	6.04	89.9	12.2	29.02	1.052	1.000	0.980	1.045

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr				
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2
1	31.5	63.25	3,310.3	13.1	2.91	29,679	1.000	--	--	--	--	--
2	11.2	32.16	1,331.4	0.6	0.88	16,281	1.000	--	--	--	--	--
3	7.8	34.10	1,234.8	0.0	0.76	12,185	1.000	--	--	--	--	--
4	3.5	60.69	1,096.7	0.4	0.76	7,878	1.000	--	--	--	--	--
5	2.0	56.58	978.5	0.1	0.71	6,487	1.000	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2001 4-stroke EFI	Test No.: UI-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (46 CID) I-3	Date: 05/23/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
BMW 4-stroke	2001 Arctic Cat ZR	Chassis E10 5-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.3 (29.04)	98.3 (29.03)	98.3 (29.03)	98.3 (29.02)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.6 (78.0) / 9.8	25.6 (78.0) / 10.5	25.6 (78.0) / 10.5	25.6 (78.0) / 9.8
Engine Air Dew Pt., °C (°F)	14.4 (57.9)	14.3 (57.8)	14.8 (58.6)	15.2 (59.3)
Engine Air Temp, °C (°F)	28.5 (83.3)	30.3 (86.6)	30.3 (86.6)	29.2 (84.6)
Engine Air: RH,% / AH, g/kg	42 / 10.6	38 / 10.5	39 / 10.9	42 / 11.1
NOx Humidity C.F.	.996	.995	1.005	1.014
Dry-to-Wet C.F.	.975	.978	.979	.981
Time, seconds	300.1	300.2	300.2	300.1
Tot. Blower Rate, scmm (scfm)*	26.12 (989.7)	26.16 (991.4)	26.33 (997.9)	26.50 (1,004.1)
90mm Sample Rate, scmm (scfm)*	0.0557 (2.11)	0.0548 (2.08)	0.0549 (2.08)	0.0556 (2.11)
Total Volume, scm (scf)*	130.9 (4,961)	131.2 (4,971)	132.0 (5,003)	132.8 (5,033)
HC Sample Meter/Range/ppm	8.0/1,000/80.2	44.0/100/44.6	45.2/100/45.8	72.2/100/72.5
HC Bckgrd Meter/Range/ppm	1.7/1,000/17.0	12.1/100/12.4	11.4/100/11.7	11.4/100/11.7
CO Sample Meter/Range/ppm (Dry)	54.1/6,000/1,753.7	74.1/1,000/697.9	69.3/1,000/640.7	62.6/1,000/564.2
CO Bckgrd Meter/Range/ppm	0.3/6,000/5.8	0.2/1,000/1.4	0.1/1,000/0.7	0.2/1,000/1.4
CO2 Sample Meter/Range/% (Wet)	50.5/2/1.0119	59.8/1/0.5742	46.5/1/0.4395	32.3/1/0.3008
CO2 Bckgrd Meter/Range/%	2.7/2/0.0541	5.4/1/0.0494	5.4/1/0.0494	5.5/1/0.0503
NOx Sample Meter/Range/ppm (Wet)	18.0/25/4.5	1.7/25/0.4	1.1/25/0.3	1.6/25/0.4
NOx Bckgrd Meter/Range/ppm	1.9/25/0.5	1.0/25/0.3	1.3/25/0.3	1.1/25/0.3
Dilution Factor	11.26	20.71	26.44	36.86
HC Concentration, ppm	64.65	32.82	34.57	61.16
CO Concentration, ppm	1,687.19	677.44	624.20	550.97
CO2 Concentration, %	0.96	0.53	0.39	0.25
NOx Concentration, ppm	4.07	0.20	0.00	0.13
HC Mass, grams	5.27	2.68	2.84	5.06
CO Mass, grams	275.95	111.02	102.97	91.42
CO2 Mass, grams	2,474.05	1,357.65	1,016.08	656.72
NOx Mass, grams	1.09	0.05	0.00	0.04
Part. Mass, grams	0.243	0.074	0.063	0.063
Fuel, kg (lb)	0.977 (2.15)	0.515 (1.13)	0.396 (0.87)	0.272 (0.60)
KW-HR (hp-hr)	1.96 (2.62)	0.70 (0.93)	0.48 (0.65)	0.22 (0.29)
Filter Number	8715.0-55	8732.0-56	8733.0-57	8734.0-58
Weight Gain, mg	0.517	0.154	0.131	0.132
Sample Multiplier	0.470	0.478	0.481	0.477
Blower 1, scf	4,950.2	4,960.2	4,993.0	5,022.1
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.975	6.954	6.960	6.870
Gas Meter 2, scf	17.534	17.343	17.369	17.413

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2001 4-stroke EFI	Test No.: UI-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (46 CID) I-3	Date: 05/23/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
BMW 4-stroke	2001 Arctic Cat ZR	Chassis E10 5-mode

Mode Number	5
Barometer, kPa (in Hg)	98.3 (29.02)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.8
Engine Air Dew Pt., °C (°F)	16.6 (61.8)
Engine Air Temp, °C (°F)	32.2 (89.9)
Engine Air: RH,% / AH, g/kg	39 / 12.2
NOx Humidity C.F.	1.052
Dry-to-Wet C.F.	.980
Time, seconds	299.9
Tot. Blower Rate, scmm (scfm)*	26.46 (1,002.8)
90mm Sample Rate, scmm (scfm)*	0.0553 (2.10)
Total Volume, scm (scf)*	132.5 (5,023)
HC Sample Meter/Range/ppm	66.7/100/67.1
HC Bckgrd Meter/Range/ppm	10.0/100/10.3
CO Sample Meter/Range/ppm (Dry)	57.1/1,000/504.0
CO Bckgrd Meter/Range/ppm	0.1/1,000/0.7
CO2 Sample Meter/Range/% (Wet)	27.6/1/0.2559
CO2 Bckgrd Meter/Range/%	5.4/1/0.0494
NOx Sample Meter/Range/ppm (Wet)	1.3/25/0.3
NOx Bckgrd Meter/Range/ppm	1.2/25/0.3
Dilution Factor	42.94
HC Concentration, ppm	57.09
CO Concentration, ppm	492.22
CO2 Concentration, %	0.21
NOx Concentration, ppm	0.04
HC Mass, grams	4.71
CO Mass, grams	81.51
CO2 Mass, grams	540.37
NOx Mass, grams	0.01
Part. Mass, grams	0.059
Fuel, kg (lb)	0.228 (0.50)
KW-HR (hp-hr)	0.12 (0.17)
Filter Number	8735.0-59
Weight Gain, mg	0.124
Sample Multiplier	0.479
Blower 1, scf	5,012.3
Blower 2, scf	0.0
Gas Meter 1, scf	6.841
Gas Meter 2, scf	17.322

* scf at 68°F and scm at 0 °C

University of Idaho
 2001 Arctic Cat ZR
 Test No: UI-GHOL-1
 Date: 5/23/02

Emissions vs. MPH, Chassis Dynamometer Test
 Engine: BMW 4-Stroke
 Displacement: 750cc
 Rated Speed: 7400 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	Speed	Mode Duration	Distance	Power	C-B Fuel	Emissions					Brake-Specific Emissions				
						HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
						grams/hr					grams/hp-hr				
mph	sec	miles	hp	lb/hr											
UI-GHOL-1	65	300.1	5.42	31.5	25.83	63.25	3,310.30	13.10	2.91	29,679	2.01	105.09	0.42	0.09	942.19
	45	300.2	3.75	11.2	13.61	32.16	1,331.40	0.60	0.88	16,281	2.87	118.88	0.05	0.08	1453.66
	35	300.2	2.92	7.8	10.48	34.10	1,234.80	0.00	0.76	12,185	4.37	158.31	0.00	0.10	1562.18
	25	300.1	2.08	3.5	7.21	60.69	1,096.70	0.40	0.76	7,878	17.34	313.34	0.11	0.22	2250.86
	15	299.9	1.25	2	6.04	56.58	978.50	0.10	0.71	6,487	28.29	489.25	0.05	0.36	3243.50

Emissions				
HC	CO	NOx	Part.	CO ₂
grams/mile				
0.97	50.93	0.20	0.04	456.60
0.71	29.59	0.01	0.02	361.80
0.97	35.28	0.00	0.02	348.14
2.43	43.87	0.02	0.03	315.12
3.77	65.23	0.01	0.05	432.47

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2001 4-stroke EFI	Test No.: UI-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (46 CID) I-3	Date: 05/23/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
BMW 4-stroke	2001 Arctic Cat ZR	Chassis E10 4-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	7,400	100.0	88.1	300	7,200	88.1	26.22	87.6	8.9	29.00	0.943	1.000	0.974	1.037
2	6,290	51.0	44.9	300	6,100	46.6	13.89	85.2	8.9	28.99	0.943	1.000	0.977	1.034
3	5,500	33.0	29.1	300	5,400	32.1	9.56	80.2	8.8	28.98	0.942	1.000	0.980	1.028
4	1,300	0.0	0.0	300	1,300	0.1	1.46	77.1	8.5	28.97	0.933	1.000	0.984	1.024

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	33.0	72.37	4,089.5	8.3	1.35	28,948	1.000	2.19	124.01	0.25	0.04	877.83	1
2	12.1	18.82	906.7	0.3	0.99	17,375	1.000	1.56	75.04	0.02	0.08	1,437.88	2
3	6.1	34.92	1,035.0	0.4	0.76	11,241	1.000	5.73	169.73	0.07	0.12	1,843.37	3
4	0.0	4.91	19.5	0.0	0.56	1,933	1.000	--	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2001 4-stroke EFI	Test No.: UI-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.8 L (46 CID) I-3	Date: 05/23/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
BMW 4-stroke	2001 Arctic Cat ZR	Chassis E10 4-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.2 (29.00)	98.2 (28.99)	98.1 (28.98)	98.1 (28.97)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.1	25.0 (77.0) / 10.8	25.0 (77.0) / 10.1	24.4 (76.0) / 9.6
Engine Air Dew Pt., °C (°F)	11.7 (53.1)	11.7 (53.1)	11.7 (53.0)	11.1 (52.0)
Engine Air Temp, °C (°F)	30.9 (87.6)	29.6 (85.2)	26.8 (80.2)	25.1 (77.1)
Engine Air: RH,% / AH, g/kg	31 / 8.9	33 / 8.9	39 / 8.8	42 / 8.5
NOx Humidity C.F.	.943	.943	.942	.933
Dry-to-Wet C.F.	.974	.977	.980	.984
Time, seconds	300.1	300.0	299.9	300.1
Tot. Blower Rate, scmm (scfm)*	26.22 (993.7)	26.32 (997.4)	26.36 (998.8)	26.40 (1,000.4)
90mm Sample Rate, scmm (scfm)*	0.0549 (2.08)	0.0549 (2.08)	0.0553 (2.10)	0.0557 (2.11)
Total Volume, scm (scf)*	131.4 (4,981)	131.9 (4,997)	132.0 (5,003)	132.3 (5,014)
HC Sample Meter/Range/ppm	80.3/100/80.5	25.0/100/25.5	39.5/100/40.1	10.3/100/10.6
HC Bckgrd Meter/Range/ppm	7.3/100/7.5	6.6/100/6.8	4.8/100/4.9	5.5/100/5.7
CO Sample Meter/Range/ppm (Wet)	59.7/6,000/2,076.0	52.8/1,000/458.6	58.9/1,000/523.4	12.0/100/11.5
CO Bckgrd Meter/Range/ppm	0.0/6,000/0.0	0.0/1,000/0.0	0.1/1,000/0.7	1.8/100/1.7
CO2 Sample Meter/Range/% (Wet)	49.0/2/0.9826	62.8/1/0.6053	43.6/1/0.4107	12.2/1/0.1119
CO2 Bckgrd Meter/Range/%	2.6/2/0.0521	5.3/1/0.0484	5.6/1/0.0512	5.5/1/0.0503
NOx Sample Meter/Range/ppm (Wet)	11.6/25/2.9	1.3/25/0.3	1.3/25/0.3	0.6/25/0.2
NOx Bckgrd Meter/Range/ppm	0.8/25/0.2	1.0/25/0.3	0.8/25/0.2	0.7/25/0.2
Dilution Factor	11.18	20.49	28.67	117.37
HC Concentration, ppm	73.68	19.09	35.37	4.97
CO Concentration, ppm	2,076.03	458.63	522.76	9.84
CO2 Concentration, %	0.94	0.56	0.36	0.06
NOx Concentration, ppm	2.72	0.10	0.14	0.00
HC Mass, grams	6.03	1.57	2.91	0.41
CO Mass, grams	340.91	75.56	86.22	1.63
CO2 Mass, grams	2,413.15	1,447.95	936.43	161.15
NOx Mass, grams	0.69	0.02	0.04	0.00
Part. Mass, grams	0.113	0.082	0.063	0.047
Fuel, kg (lb)	0.991 (2.19)	0.525 (1.16)	0.361 (0.80)	0.055 (0.12)
KW-HR (hp-hr)	2.05 (2.75)	0.75 (1.01)	0.38 (0.51)	0.00 (0.00)
Filter Number	8736.0-60	8737.0-61	8738.0-62	8740.0-64
Weight Gain, mg	0.235	0.171	0.132	0.099
Sample Multiplier	0.479	0.480	0.477	0.475
Blower 1, scf	4,970.2	4,986.8	4,992.3	5,003.8
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	6.874	6.831	6.801	6.830
Gas Meter 2, scf	17.274	17.238	17.281	17.390

* scf at 68°F and scm at 0°C

University of Idaho
 2001 Arctic Cat ZR
 Test No: UI-GHOL-2
 Date: 5/23/02

4-Mode Chassis Dynamometer Test
 Engine: BMW 4-Stroke
 Displacement: 750cc
 Rated Speed: 7400 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	% of Rated Engine Speed	% of Maximum Torque	Engine Speed	Vehicle Speed	Mode Duration	Distance	Modal Weight Factor	Power	C-B Fuel	Mass Emissions					Unweighted Brake-Specific Modal Emissions				
			RPM	mph	sec	miles	%	hp	lb/hr	HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
												grams/hr					grams/hp-hr		
UI-GHOL-2	100	100	7400	65	300.1	5.42	18	33	26.22	72.37	4,089.50	8.30	1.35	28,948	2.19	123.92	0.25	0.04	877.21
	85	51	6290	45	300	3.75	39	12.1	13.89	18.82	906.70	0.30	0.99	17,375	1.56	74.93	0.02	0.08	1435.95
	75	33	5550	33	299.9	2.75	36	6.1	9.56	34.92	1,035.00	0.40	0.76	11,241	5.72	169.67	0.07	0.12	1842.79
	Idle	0	1300	0	300.1	0.00	7	0	1.46	4.91	19.50	0.00	0.56	1,933	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Hourly Composite Emissions		
HC	grams/hr	33.28
CO	grams/hr	1463.69
NOx	grams/hr	1.76
Part.	grams/hr	0.94
CO ₂	grams/hr	16169

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	2.59
BSCO	grams/hp-hr	113.86
BSNOx	grams/hp-hr	0.14
BSPart.	grams/hp-hr	0.07
BSCO ₂	grams/hp-hr	1258
BSFC	lb/hp-hr	1.064

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E10 5-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,200	0.0	0.0	117	6,350	95.0	42.24	85.2	12.0	29.11	1.044	1.000	0.974	1.035
2	6,000	0.0	0.0	123	5,950	102.0	30.54	82.4	10.8	29.11	1.004	1.000	0.977	1.030
3	5,500	0.0	0.0	231	5,500	90.7	21.30	81.3	10.4	29.10	0.991	1.000	0.979	1.028
4	4,650	0.0	0.0	235	4,650	43.5	7.26	82.4	10.5	29.09	0.994	1.000	0.979	1.030
5	3,900	0.0	0.0	210	3,900	40.5	5.29	81.6	10.1	29.09	0.982	1.000	0.980	1.028

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr				
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2
1	35.6	200.05	19,178.7	1.2	5.45	26,601	1.000	--	--	--	--	--
2	27.0	137.98	13,333.4	0.6	2.29	20,086	1.000	--	--	--	--	--
3	18.3	91.00	8,178.9	0.3	1.27	15,788	1.000	--	--	--	--	--
4	6.3	1.35	28.3	4.2	0.73	9,809	1.000	--	--	--	--	--
5	3.5	0.21	0.4	32.3	0.76	7,183	1.000	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E10 5-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.6 (29.11)	98.6 (29.11)	98.5 (29.10)	98.5 (29.09)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.7	24.4 (76.0) / 10.3	25.0 (77.0) / 10.0	25.0 (77.0) / 10.7
Engine Air Dew Pt., °C (°F)	16.3 (61.4)	14.8 (58.6)	14.2 (57.6)	14.3 (57.8)
Engine Air Temp, °C (°F)	29.6 (85.2)	28.0 (82.4)	27.4 (81.3)	28.0 (82.4)
Engine Air: RH,% / AH, g/kg	45 / 12.0	44 / 10.8	44 / 10.4	43 / 10.5
NOx Humidity C.F.	1.044	1.004	.991	.994
Dry-to-Wet C.F.	.974	.977	.979	.979
Time, seconds	116.7	123.3	230.7	235.2
Tot. Blower Rate, scmm (scfm)*	26.03 (986.4)	26.12 (989.8)	26.21 (993.0)	26.25 (994.8)
90mm Sample Rate, scmm (scfm)*	0.0555 (2.10)	0.0548 (2.08)	0.0548 (2.08)	0.0548 (2.08)
Total Volume, scm (scf)*	50.7 (1,923)	53.8 (2,038)	101.0 (3,826)	103.1 (3,908)
HC Sample Meter/Range/ppm	20.9/1,000/209.5	14.7/1,000/147.3	9.9/1,000/99.2	6.4/100/6.6
HC Bckgrd Meter/Range/ppm	0.5/1,000/5.0	0.7/1,000/7.0	0.7/1,000/7.0	5.2/100/5.3
CO Sample Meter/Range/ppm (Dry)	83.0/15,000/10,162.5	74.4/15,000/7,011.5	84.9/6,000/4,275.0	16.5/100/15.9
CO Bckgrd Meter/Range/ppm	0.0/15,000/0.0	0.1/15,000/2.5	0.3/6,000/5.8	1.2/100/1.2
CO2 Sample Meter/Range/% (Wet)	45.4/2/0.9120	34.6/2/0.6981	58.2/1/0.5578	38.9/1/0.3646
CO2 Bckgrd Meter/Range/%	2.7/2/0.0541	2.6/2/0.0521	5.6/1/0.0512	5.4/1/0.0494
NOx Sample Meter/Range/ppm (Wet)	3.3/25/0.8	3.0/25/0.8	2.7/25/0.7	7.1/25/1.8
NOx Bckgrd Meter/Range/ppm	2.2/25/0.6	2.5/25/0.6	2.6/25/0.7	2.0/25/0.5
Dilution Factor	7.00	9.62	13.61	36.51
HC Concentration, ppm	205.18	141.04	92.72	1.38
CO Concentration, ppm	9,807.34	6,795.08	4,154.81	14.37
CO2 Concentration, %	0.87	0.65	0.51	0.32
NOx Concentration, ppm	0.37	0.19	0.09	1.30
HC Mass, grams	6.48	4.73	5.83	0.09
CO Mass, grams	621.71	456.67	524.13	1.85
CO2 Mass, grams	862.31	687.95	1,011.72	640.88
NOx Mass, grams	0.04	0.02	0.02	0.27
Part. Mass, grams	0.177	0.078	0.081	0.048
Fuel, kg (lb)	0.621 (1.37)	0.474 (1.05)	0.619 (1.36)	0.215 (0.47)
KW-HR (hp-hr)	0.86 (1.15)	0.69 (0.93)	0.87 (1.17)	0.30 (0.41)
Filter Number	8708.0-36	8696.0-37	8697.0-38	8698.0-39
Weight Gain, mg	0.376	0.164	0.170	0.100
Sample Multiplier	0.470	0.477	0.479	0.480
Blower 1, scf	1,918.6	2,034.1	3,818.2	3,899.5
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	2.720	2.872	5.361	5.407
Gas Meter 2, scf	6.812	7.141	13.342	13.550

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-GHOL-1	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E10 5-mode

Mode Number	5
Barometer, kPa (in Hg)	98.5 (29.09)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.7
Engine Air Dew Pt., °C (°F)	13.8 (56.8)
Engine Air Temp, °C (°F)	27.6 (81.6)
Engine Air: RH,% / AH, g/kg	43 / 10.1
NOx Humidity C.F.	.982
Dry-to-Wet C.F.	.980
Time, seconds	210.1
Tot. Blower Rate, scmm (scfm)*	26.37 (999.4)
90mm Sample Rate, scmm (scfm)*	0.0551 (2.09)
Total Volume, scm (scf)*	92.5 (3,507)
HC Sample Meter/Range/ppm	5.5/100/5.7
HC Bckgrd Meter/Range/ppm	5.4/100/5.6
CO Sample Meter/Range/ppm (Dry)	1.8/100/1.7
CO Bckgrd Meter/Range/ppm	1.6/100/1.5
CO2 Sample Meter/Range/% (Wet)	30.4/1/0.2826
CO2 Bckgrd Meter/Range/%	5.8/1/0.0530
NOx Sample Meter/Range/ppm (Wet)	43.2/25/10.8
NOx Bckgrd Meter/Range/ppm	2.9/25/0.7
Dilution Factor	47.27
HC Concentration, ppm	0.22
CO Concentration, ppm	0.21
CO2 Concentration, %	0.23
NOx Concentration, ppm	10.11
HC Mass, grams	0.01
CO Mass, grams	0.02
CO2 Mass, grams	419.21
NOx Mass, grams	1.88
Part. Mass, grams	0.044
Fuel, kg (lb)	0.140 (0.31)
KW-HR (hp-hr)	0.15 (0.20)
Filter Number	8699.0-40
Weight Gain, mg	0.092
Sample Multiplier	0.479
Blower 1, scf	3,499.7
Blower 2, scf	0.0
Gas Meter 1, scf	4.819
Gas Meter 2, scf	12.134

* scf at 68°F and scm at 0 °C

Kettering University
 2000 Yamaha V-Max
 Test No: KETT-GHOL-1
 Date: 5/22/02

Emissions vs. MPH, Chassis Dynamometer Test
 Engine: Daihatsu 4-Stroke
 Displacement: 660cc
 Rated Speed: 6200 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	Speed	Mode Duration	Distance	Power	C-B Fuel	Emissions					Brake-Specific Emissions				
						HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
						grams/hr					grams/hp-hr				
	mph	sec	miles	hp	lb/hr										
KETT-GHOL-1	65	116.7	2.11	35.6	42.24	200.05	19,178.70	1.20	5.45	26,601	5.62	538.73	0.03	0.15	747.22
	45	123.3	1.54	27.0	30.54	137.98	13,333.40	0.60	2.29	20,086	5.11	493.83	0.02	0.08	743.93
	35	230.7	2.24	18.3	21.30	91.00	8,178.90	0.30	1.27	15,788	4.97	446.93	0.02	0.07	862.73
	25	235.2	1.63	6.3	7.26	1.35	28.30	4.20	0.73	9,809	0.21	4.49	0.67	0.12	1556.98
	15	210.1	0.88	3.5	5.29	0.21	0.40	32.30	0.76	7,183	0.06	0.11	9.23	0.22	2052.29

Emissions				
HC	CO	NOx	Part.	CO ₂
grams/mile				
3.08	295.06	0.02	0.08	409.25
3.07	296.30	0.01	0.05	446.36
2.60	233.68	0.01	0.04	451.09
0.05	1.13	0.17	0.03	392.36
0.01	0.03	2.15	0.05	478.87

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E10 4-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,200	100.0	115.0	214	6,275	115.0	42.75	83.4	10.5	29.08	0.994	1.000	0.977	1.031
2	5,270	51.0	58.7	214	5,300	60.0	14.96	82.4	9.6	29.08	0.966	1.000	0.979	1.028
3	4,650	33.0	38.0	216	4,660	40.0	7.37	81.9	9.9	29.08	0.973	1.000	0.980	1.029
4	1,300	0.0	0.0	300	1,300	1.0	1.07	81.9	9.5	29.07	0.963	1.000	0.983	1.028

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	35.8	299.47	21,342.1	1.0	5.19	23,604	1.000	8.37	596.46	0.03	0.14	659.67	1
2	12.8	45.59	3,720.3	0.1	1.01	14,322	1.000	3.56	290.82	0.01	0.08	1,119.58	2
3	6.7	0.82	17.2	5.8	0.93	9,971	1.000	0.12	2.57	0.86	0.14	1,491.19	3
4	0.0	0.03	0.0	0.4	0.74	1,455	1.000	--	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-GHOL-2	GASOLINE GHOL, EM-4611-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/22/2002 Time:	HCR: 1.940 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.133 C= 0.817 O= 0.050 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E10 4-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.5 (29.08)	98.5 (29.08)	98.4 (29.08)	98.4 (29.07)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 9.3	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0
Engine Air Dew Pt., °C (°F)	14.3 (57.8)	13.0 (55.4)	13.3 (56.0)	12.8 (55.1)
Engine Air Temp, °C (°F)	28.6 (83.4)	28.0 (82.4)	27.7 (81.9)	27.7 (81.9)
Engine Air: RH,% / AH, g/kg	42 / 10.5	40 / 9.6	41 / 9.9	40 / 9.5
NOx Humidity C.F.	.994	.966	.973	.963
Dry-to-Wet C.F.	.977	.979	.980	.983
Time, seconds	214.1	213.6	215.9	300.4
Tot. Blower Rate, scmm (scfm)*	26.42 (1,001.1)	26.57 (1,006.8)	26.65 (1,009.9)	26.64 (1,009.4)
90mm Sample Rate, scmm (scfm)*	0.0550 (2.08)	0.0552 (2.09)	0.0546 (2.07)	0.0553 (2.09)
Total Volume, scm (scf)*	94.5 (3,580)	94.8 (3,592)	96.1 (3,641)	133.6 (5,064)
HC Sample Meter/Range/ppm	30.8/1,000/308.7	49.8/100/50.4	4.4/100/4.5	4.2/100/4.3
HC Bckgrd Meter/Range/ppm	0.7/1,000/7.0	4.7/100/4.8	3.7/100/3.8	4.2/100/4.3
CO Sample Meter/Range/ppm (Dry)	85.0/15,000/11,100.1	57.0/6,000/1,915.2	12.4/100/11.9	1.7/100/1.6
CO Bckgrd Meter/Range/ppm	0.3/15,000/7.5	0.1/6,000/1.9	3.3/100/3.2	1.7/100/1.6
CO2 Sample Meter/Range/% (Wet)	81.2/1/0.8008	52.7/1/0.5017	39.3/1/0.3685	10.6/1/0.0971
CO2 Bckgrd Meter/Range/%	5.6/1/0.0512	5.2/1/0.0475	5.8/1/0.0530	5.6/1/0.0512
NOx Sample Meter/Range/ppm (Wet)	3.0/25/0.8	1.3/25/0.3	9.1/25/2.3	2.3/25/0.6
NOx Bckgrd Meter/Range/ppm	2.1/25/0.5	1.3/25/0.3	2.0/25/0.5	1.8/25/0.5
Dilution Factor	7.02	19.32	36.18	137.09
HC Concentration, ppm	302.67	45.82	0.83	0.03
CO Concentration, ppm	10,754.38	1,864.07	8.60	0.01
CO2 Concentration, %	0.76	0.46	0.32	0.05
NOx Concentration, ppm	0.30	0.02	1.80	0.14
HC Mass, grams	17.81	2.71	0.05	0.00
CO Mass, grams	1,269.26	220.74	1.03	0.00
CO2 Mass, grams	1,403.77	849.76	597.97	121.41
NOx Mass, grams	0.06	0.00	0.35	0.04
Part. Mass, grams	0.308	0.060	0.056	0.062
Fuel, kg (lb)	1.153 (2.54)	0.402 (0.89)	0.200 (0.44)	0.041 (0.09)
KW-HR (hp-hr)	1.59 (2.13)	0.57 (0.76)	0.30 (0.40)	0.00 (0.00)
Filter Number	8700.0-41	8701.0-42	8702.0-43	8703.0-44
Weight Gain, mg	0.641	0.124	0.114	0.128
Sample Multiplier	0.481	0.483	0.489	0.483
Blower 1, scf	3,572.3	3,584.2	3,633.8	5,053.7
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	4.913	4.884	5.006	6.882
Gas Meter 2, scf	12.351	12.326	12.453	17.366

* scf at 68°F and scm at 0°C

Kettering University
 2000 Yamaha V-Max
 Test No: KETT-GHOL-2
 Date: 5/22/02

4-Mode Chassis Dynamometer Test
 Engine: Daihatsu 4-Stroke
 Displacement: 660cc
 Rated Speed: 6200 RPM

Fuel: E10 (Gasohol)
 SwRI

Test No.	% of Rated Engine Speed	% of Maximum Torque	Engine Speed	Vehicle Speed	Mode Duration	Distance	Modal Weight Factor	Power	C-B Fuel	Mass Emissions					Unweighted Brake-Specific Modal Emissions				
										HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
			RPM	mph	sec	miles	%	hp	lb/hr	grams/hr					grams/hp-hr				
KETT-GHOL-2	100	100	6275	57	214.1	3.39	18	35.8	42.75	299.47	21,342.10	1.00	5.19	23,604	8.37	596.15	0.03	0.14	659.33
	85	51	5200	38	213.6	2.25	39	12.8	14.96	45.59	3,720.30	0.10	1.01	14,322	3.56	290.65	0.01	0.08	1118.91
	75	33	4700	30	215.9	1.80	36	6.7	7.37	0.82	17.20	5.80	0.93	9,971	0.12	2.57	0.87	0.14	1488.21
	Idle	0	1300	0	300.4	0.00	7	0	1.07	0.03	0.00	0.40	0.74	1,455	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Hourly Composite Emissions		
HC	grams/hr	71.98
CO	grams/hr	5298.69
NOx	grams/hr	2.34
Part.	grams/hr	1.71
CO ₂	grams/hr	13526

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	5.20
BSCO	grams/hp-hr	382.63
BSNOx	grams/hp-hr	0.17
BSPart.	grams/hp-hr	0.12
BSCO ₂	grams/hp-hr	977
BSFC	lb/hp-hr	1.174

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-E85-5M	ETHANOL E85, EM-4635-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/24/2002 Time:	HCR: 2.813 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.127 C= 0.538 O= 0.335 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E85 5-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,200	0.0	0.0	148	6,200	95.0	61.95	96.0	15.1	29.07	1.170	1.000	0.972	1.056
2	6,000	0.0	0.0	184	5,900	98.1	39.49	84.6	12.8	29.08	1.072	1.000	0.974	1.037
3	5,500	0.0	0.0	203	5,600	76.1	24.61	80.6	11.9	29.08	1.040	1.000	0.976	1.030
4	4,650	0.0	0.0	210	4,700	59.2	12.86	79.9	12.0	29.08	1.044	1.000	0.977	1.029
5	3,900	0.0	0.0	212	3,900	46.7	7.88	79.1	12.0	29.08	1.044	1.000	0.979	1.028

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr				
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2
1	35.6	278.68	18,563.8	0.4	1.78	25,653	1.000	--	--	--	--	--
2	24.9	139.19	9,718.8	0.3	0.76	19,753	1.000	--	--	--	--	--
3	15.3	41.48	3,520.5	0.1	0.35	16,386	1.000	--	--	--	--	--
4	8.5	0.64	25.6	0.0	0.20	11,452	1.000	--	--	--	--	--
5	4.3	0.35	0.4	25.2	0.11	7,043	1.000	--	--	--	--	--

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-E85-5M	ETHANOL E85, EM-4635-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/24/2002 Time:	HCR: 2.813 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.127 C= 0.538 O= 0.335 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E85 5-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.4 (29.07)	98.5 (29.08)	98.5 (29.08)	98.5 (29.08)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0	25.0 (77.0) / 10.0	25.6 (78.0) / 10.5
Engine Air Dew Pt., °C (°F)	19.9 (67.9)	17.3 (63.1)	16.2 (61.1)	16.3 (61.4)
Engine Air Temp, °C (°F)	35.6 (96.0)	29.2 (84.6)	27.0 (80.6)	26.6 (79.9)
Engine Air: RH,% / AH, g/kg	40 / 15.1	49 / 12.8	52 / 11.9	53 / 12.0
NOx Humidity C.F.	1.170	1.072	1.040	1.044
Dry-to-Wet C.F.	.972	.974	.976	.977
Time, seconds	148.2	184.1	203.0	210.3
Tot. Blower Rate, scmm (scfm)*	26.06 (987.4)	26.11 (989.6)	26.23 (994.0)	26.22 (993.6)
90mm Sample Rate, scmm (scfm)*	0.0562 (2.13)	0.0565 (2.14)	0.0565 (2.14)	0.0576 (2.18)
Total Volume, scm (scf)*	64.5 (2,444)	80.3 (3,043)	88.9 (3,370)	92.1 (3,490)
HC Sample Meter/Range/ppm	27.4/1,000/274.6	13.9/1,000/139.3	44.7/100/45.3	6.4/100/6.6
HC Bckgrd Meter/Range/ppm	0.7/1,000/7.0	0.6/1,000/6.0	5.8/100/6.0	6.0/100/6.2
CO Sample Meter/Range/ppm (Dry)	83.2/15,000/9,849.8	91.2/6,000/5,121.8	55.7/6,000/1,841.4	14.8/100/14.2
CO Bckgrd Meter/Range/ppm	0.1/15,000/2.5	0.1/6,000/1.9	0.0/6,000/0.0	0.9/100/0.9
CO2 Sample Meter/Range/% (Wet)	88.1/1/0.8761	70.6/1/0.6871	60.1/1/0.5773	44.4/1/0.4186
CO2 Bckgrd Meter/Range/%	5.4/1/0.0494	5.6/1/0.0512	5.6/1/0.0512	5.5/1/0.0503
NOx Sample Meter/Range/ppm (Wet)	1.2/25/0.3	1.2/25/0.3	1.0/25/0.3	0.9/25/0.2
NOx Bckgrd Meter/Range/ppm	0.9/25/0.2	1.0/25/0.3	1.0/25/0.3	1.0/25/0.3
Dilution Factor	6.81	10.54	16.58	29.97
HC Concentration, ppm	268.62	133.87	39.72	0.62
CO Concentration, ppm	9,483.63	4,954.07	1,786.60	13.02
CO2 Concentration, %	0.83	0.64	0.53	0.37
NOx Concentration, ppm	0.11	0.08	0.02	0.00
HC Mass, grams	11.47	7.12	2.34	0.04
CO Mass, grams	764.21	497.01	198.52	1.50
CO2 Mass, grams	1,056.03	1,010.16	924.01	669.01
NOx Mass, grams	0.02	0.01	0.00	0.00
Part. Mass, grams	0.073	0.039	0.020	0.012
Fuel, kg (lb)	1.157 (2.55)	0.916 (2.02)	0.629 (1.39)	0.341 (0.75)
KW-HR (hp-hr)	1.09 (1.46)	0.95 (1.27)	0.65 (0.87)	0.37 (0.50)
Filter Number	8751.0-4	8750.0-3	8750.0-2	8749.0-1
Weight Gain, mg	0.158	0.084	0.042	0.026
Sample Multiplier	0.464	0.463	0.465	0.457
Blower 1, scf	2,438.8	3,036.3	3,362.9	3,482.5
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	3.378	4.178	4.635	4.806
Gas Meter 2, scf	8.642	10.745	11.879	12.451

* scf at 68°F and scm at 0°C

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-E85-5M	ETHANOL E85, EM-4635-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/24/2002 Time:	HCR: 2.813 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.127 C= 0.538 O= 0.335 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E85 5-mode

Mode Number	5
Barometer, kPa (in Hg)	98.5 (29.08)
Dil. Air: Temp, °C (°F) / AH, g/kg	23.3 (74.0) / 10.8
Engine Air Dew Pt., °C (°F)	16.3 (61.4)
Engine Air Temp, °C (°F)	26.2 (79.1)
Engine Air: RH,% / AH, g/kg	55 / 12.0
NOx Humidity C.F.	1.044
Dry-to-Wet C.F.	.979
Time, seconds	212.2
Tot. Blower Rate, scmm (scfm)*	26.21 (993.3)
90mm Sample Rate, scmm (scfm)*	0.0583 (2.21)
Total Volume, scm (scf)*	92.9 (3,521)
HC Sample Meter/Range/ppm	5.8/100/6.0
HC Bckgrd Meter/Range/ppm	5.6/100/5.8
CO Sample Meter/Range/ppm (Dry)	1.1/100/1.1
CO Bckgrd Meter/Range/ppm	0.9/100/0.9
CO2 Sample Meter/Range/% (Wet)	29.7/1/0.2759
CO2 Bckgrd Meter/Range/%	5.4/1/0.0494
NOx Sample Meter/Range/ppm (Wet)	35.4/25/8.9
NOx Bckgrd Meter/Range/ppm	5.8/25/1.5
Dilution Factor	45.58
HC Concentration, ppm	0.34
CO Concentration, ppm	0.20
CO2 Concentration, %	0.23
NOx Concentration, ppm	7.46
HC Mass, grams	0.02
CO Mass, grams	0.02
CO2 Mass, grams	415.15
NOx Mass, grams	1.48
Part. Mass, grams	0.006
Fuel, kg (lb)	0.211 (0.46)
KW-HR (hp-hr)	0.19 (0.25)
Filter Number	8741.0-65
Weight Gain, mg	0.014
Sample Multiplier	0.451
Blower 1, scf	3,513.1
Blower 2, scf	0.0
Gas Meter 1, scf	4.948
Gas Meter 2, scf	12.763
* scf at 68°F and scm at 0 °C	

Kettering University
 2000 Yamaha V-Max
 Test No: KETT-E85-5m
 Date: 5/24/02

Emissions vs. MPH, Chassis Dynamometer Test
 Engine: Daihatsu 4-Stroke
 Displacement: 660cc
 Rated Speed: 6200 RPM

Fuel: E85 (85%Ethanol)
 SwRI

Test No.	Speed	Mode Duration	Distance	Power	C-B Fuel	Emissions					Brake-Specific Emissions				
						HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
						grams/hr					grams/hp-hr				
mph	sec	miles	hp	lb/hr											
KETT-E85-5m	65	148.2	2.68	35.6	61.95	278.68	18,563.80	0.40	1.78	25,653	7.83	521.46	0.01	0.05	720.59
	45	184.1	2.30	24.9	39.49	139.19	9,718.80	0.30	0.76	19,753	5.59	390.31	0.01	0.03	793.29
	35	203.0	1.97	15.3	24.61	41.48	3,520.50	0.10	0.35	16,386	2.71	230.10	0.01	0.02	1070.98
	25	210.3	1.46	8.5	12.86	0.64	25.60	0.00	0.20	11,452	0.08	3.01	0.00	0.02	1347.29
	15	212.2	0.88	4.3	7.88	0.35	0.40	25.20	0.11	7,043	0.08	0.09	5.86	0.03	1637.91

Emissions				
HC	CO	NOx	Part.	CO ₂
grams/mile				
4.29	285.60	0.01	0.03	394.66
3.09	215.97	0.01	0.02	438.96
1.19	100.59	0.00	0.01	468.17
0.03	1.02	0.00	0.01	458.08
0.02	0.03	1.68	0.01	469.53

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-E85-4m	ETHANOL E85, EM-4635-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/24/2002 Time:	HCR: 2.813 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.127 C= 0.538 O= 0.335 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E85 4-mode

Mode	Target			Time sec	Measured		C - B Fuel lb/hr	Intake Air			Factors			
	Speed rpm	Load pct	Torque lb-ft		Speed rpm	Torque lb-ft		Temp °F	Humid g/kg	Baro. in-Hg	NOx Hum.	Part. Hum.	Dry Wet	F (NA)
1	6,200	100.0	119.4	105	6,150	119.4	69.82	82.6	12.4	29.07	1.061	1.000	0.967	1.034
2	5,270	51.0	60.9	211	5,300	59.1	16.19	82.0	11.7	29.07	1.035	1.000	0.976	1.032
3	4,650	33.0	39.4	210	4,750	40.7	11.21	83.5	12.2	29.07	1.051	1.000	0.978	1.035
4	1,600	0.0	0.0	300	1,700	0.0	1.87	83.4	11.8	29.06	1.035	1.000	0.982	1.034

Mode	BHP from Work	Grams/Hour					Mode wf	Unweighted Modal Contribution g/hp-hr					
		HC	CO	NOx	Part.	CO2		HC	CO	NOx	Part.	CO2	
1	39.9	189.50	17,827.8	0.3	1.50	34,027	1.000	4.75	447.06	0.01	0.04	853.27	1
2	11.6	4.98	408.6	0.0	0.55	13,819	1.000	0.43	35.29	0.00	0.05	1,193.36	2
3	6.3	0.59	3.6	5.3	0.42	10,018	1.000	0.09	0.56	0.83	0.07	1,581.64	3
4	0.0	8.03	3.7	0.6	0.48	1,650	1.000	--	--	--	--	--	

Southwest Research Institute - Department of Emissions Research

Custom, EPA Calcs Emission Test Results

Project No. 08-5486-001

Engine Model: 2000 4-stroke EFI	Test No.: KETT-E85-4m	ETHANOL E85, EM-4635-F
Engine Desc.: 0.7 L (40 CID) I-3	Date: 05/24/2002 Time:	HCR: 2.813 FID Resp: 1.00
Engine Cycle: Otto-Cycle	Program SSDIL: 2.28-R	H= 0.127 C= 0.538 O= 0.335 X= 0.000
Engine S/N:	Cell: 13 Bag Cart: 2	
Daihatsu 4-stroke	2000 Yamaha V-Max	Chassis E85 4-mode

Mode Number	1	2	3	4
Barometer, kPa (in Hg)	98.4 (29.07)	98.4 (29.07)	98.4 (29.07)	98.4 (29.06)
Dil. Air: Temp, °C (°F) / AH, g/kg	25.0 (77.0) / 10.8	25.6 (78.0) / 10.5	25.6 (78.0) / 10.5	25.6 (78.0) / 10.5
Engine Air Dew Pt., °C (°F)	16.9 (62.4)	16.0 (60.8)	16.6 (61.8)	16.0 (60.8)
Engine Air Temp, °C (°F)	28.1 (82.6)	27.8 (82.0)	28.6 (83.5)	28.6 (83.4)
Engine Air: RH,% / AH, g/kg	51 / 12.4	49 / 11.7	48 / 12.2	47 / 11.8
NOx Humidity C.F.	1.061	1.035	1.051	1.035
Dry-to-Wet C.F.	.967	.976	.978	.982
Time, seconds	104.9	211.4	210.3	300.0
Tot. Blower Rate, scmm (scfm)*	26.38 (999.8)	26.38 (999.7)	26.44 (1,001.9)	26.44 (1,002.0)
90mm Sample Rate, scmm (scfm)*	0.0564 (2.14)	0.0561 (2.13)	0.0561 (2.13)	0.0564 (2.14)
Total Volume, scm (scf)*	46.2 (1,752)	93.1 (3,530)	92.9 (3,519)	132.5 (5,021)
HC Sample Meter/Range/ppm	18.5/1,000/185.4	9.9/100/10.2	5.5/100/5.7	12.6/100/12.9
HC Bckgrd Meter/Range/ppm	0.6/1,000/6.0	5.5/100/5.7	5.1/100/5.2	5.2/100/5.3
CO Sample Meter/Range/ppm (Dry)	82.3/15,000/9,413.5	48.7/500/213.6	2.9/100/2.8	3.0/100/2.9
CO Bckgrd Meter/Range/ppm	0.1/15,000/2.5	0.4/500/1.5	1.0/100/1.0	1.0/100/1.0
CO2 Sample Meter/Range/% (Wet)	56.8/2/1.1344	51.3/1/0.4876	39.7/1/0.3724	11.5/1/0.1054
CO2 Bckgrd Meter/Range/%	2.5/2/0.0501	5.0/1/0.0457	5.8/1/0.0530	5.8/1/0.0530
NOx Sample Meter/Range/ppm (Wet)	2.0/25/0.5	2.4/25/0.6	9.1/25/2.3	3.2/25/0.8
NOx Bckgrd Meter/Range/ppm	2.0/25/0.5	2.5/25/0.6	3.1/25/0.8	2.6/25/0.7
Dilution Factor	6.14	24.75	33.78	117.86
HC Concentration, ppm	180.39	4.74	0.57	7.63
CO Concentration, ppm	8,994.57	206.19	1.79	1.88
CO2 Concentration, %	1.09	0.44	0.32	0.05
NOx Concentration, ppm	0.09	0.01	1.54	0.17
HC Mass, grams	5.52	0.29	0.03	0.67
CO Mass, grams	519.48	23.99	0.21	0.31
CO2 Mass, grams	991.49	811.49	585.21	137.48
NOx Mass, grams	0.01	0.00	0.31	0.05
Part. Mass, grams	0.044	0.032	0.025	0.040
Fuel, kg (lb)	0.923 (2.03)	0.431 (0.95)	0.297 (0.66)	0.071 (0.16)
KW-HR (hp-hr)	0.87 (1.16)	0.51 (0.68)	0.28 (0.37)	0.00 (0.00)
Filter Number	8753.0-5	8754.0-6	8755.0-7	8756.0-8
Weight Gain, mg	0.093	0.068	0.052	0.085
Sample Multiplier	0.469	0.471	0.472	0.470
Blower 1, scf	1,748.0	3,522.2	3,511.7	5,010.2
Blower 2, scf	0.0	0.0	0.0	0.0
Gas Meter 1, scf	2.393	4.768	4.739	6.803
Gas Meter 2, scf	6.128	12.263	12.195	17.482

* scf at 68°F and scm at 0°C

Kettering University
 2000 Yamaha V-Max
 Test No: KETT-E85-4m
 Date: 5/24/02

4-Mode Chassis Dynamometer Test
 Engine: Daihatsu 4-Stroke
 Displacement: 660cc
 Rated Speed: 6200 RPM

Fuel: E85 (85%Ethanol)
 SwRI

Test No.	% of Rated Engine Speed	% of Maximum Torque	Engine Speed	Vehicle Speed	Mode Duration	Distance	Modal Weight Factor	Power	C-B Fuel	Mass Emissions					Unweighted Brake-Specific Modal Emissions				
										HC	CO	NOx	Part.	CO ₂	HC	CO	NOx	Part.	CO ₂
			RPM	mph	sec	miles	%	hp	lb/hr	grams/hr	grams/hr	grams/hr	grams/hr	grams/hr	grams/hr	grams/hr	grams/hr		
KETT-E85-4m	100	100	6150	59	104.9	1.72	18	39.9	69.82	189.50	17,827.80	0.30	1.50	34,027	4.75	446.81	0.01	0.04	852.81
	85	51	5300	35	211.4	2.06	39	11.6	16.19	4.98	408.60	0.00	0.55	13,819	0.43	35.22	0.00	0.05	1191.29
	75	33	4750	28	210.3	1.64	36	6.3	11.21	0.59	3.60	5.30	0.42	10,018	0.09	0.57	0.84	0.07	1590.16
	Idle	0	1700	0	300	0.00	7	0	1.87	8.03	3.70	0.60	0.48	1,650	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Weighted Hourly Composite Emissions		
HC	grams/hr	36.83
CO	grams/hr	3369.91
NOx	grams/hr	2.00
Part.	grams/hr	0.67
CO ₂	grams/hr	15236

Weighted Brake-Specific Composite Emissions		
BSHC	grams/hp-hr	2.64
BSCO	grams/hp-hr	241.16
BSNOx	grams/hp-hr	0.14
BSPart.	grams/hp-hr	0.05
BSCO ₂	grams/hp-hr	1090
BSFC	lb/hp-hr	1.649

APPENDIX D

ESTIMATED SNOWMOBILE EMISSIONS (G/MI)

TABLE D-1. POLARIS SNOWMOBILE EMISSIONS IN G/MI FOR P-EEE-1

P-EEE-1	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6005	50	167.65	5,509.60	228.70	3.84	26,088.00	3.34	109.64	4.55	0.08	519.16
	5095	26	36.17	411.50	123.70	1.25	16,517.00	1.37	15.57	4.68	0.05	624.95
	4519	15	10.77	278.30	38.10	0.96	11,781.00	0.70	18.09	2.48	0.06	765.99
	3906	3	7.60	239.90	9.80	0.95	8,372.00	2.44	76.89	3.14	0.30	2,683.33
	1186	0	34.48	136.90	1.00	0.72	2,150.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-2. POLARIS SNOWMOBILE EMISSIONS IN G/MI FOR P-EEE-2

P-EEE-2	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	5993	50	156.95	4,729.80	291.00	2.61	26,557.00	3.16	95.26	5.86	0.05	534.88
	5108	27	27.48	347.20	109.60	1.15	16,081.00	1.03	13.05	4.12	0.04	604.20
	4509	15	12.36	281.60	41.40	0.94	11,924.00	0.81	18.55	2.73	0.06	785.51
	3886	3	6.94	233.10	13.60	0.79	8,154.00	2.55	85.70	5.00	0.29	2,997.79
	1182	0	36.05	138.20	1.10	0.35	2,131.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-3. AVERAGED POLARIS SNOWMOBILE EMISSIONS IN G/MI FOR GASOLINE TESTS

Polaris EEE Averages	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	5999	50	162.30	5,119.70	259.85	3.23	26,322.50	3.25	102.45	5.21	0.06	527.02
	5101.5	27	31.83	379.35	116.65	1.20	16,299.00	1.20	14.31	4.40	0.05	614.57
	4514	15	11.57	279.95	39.75	0.95	11,852.50	0.76	18.32	2.60	0.06	775.75
	3896	3	7.27	236.50	11.70	0.87	8,263.00	2.49	81.29	4.07	0.30	2,840.56
	1184	0	35.27	137.55	1.05	0.54	2,140.50	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-4. POLARIS SNOWMOBILE EMISSIONS IN G/MI FOR P-GHOL-1

P-GHOL-1	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6005	50	79.08	913.50	583.20	1.60	28,661.00	1.57	18.18	11.61	0.03	570.37
	5108	27	33.82	442.50	122.80	1.20	16,295.00	1.27	16.63	4.61	0.05	612.24
	4500	15	9.99	241.00	36.50	0.91	11,658.00	0.67	16.07	2.43	0.06	777.20
	3911	3	7.34	239.20	14.00	0.76	8,280.00	2.28	74.29	4.35	0.24	2,571.43
	1206	0	43.62	146.20	1.00	0.73	2,090.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-5. POLARIS SNOWMOBILE EMISSIONS IN G/MI FOR P-GHOL-2

P-GHOL-2	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6000	50	115.90	2,315.00	450.10	1.60	28,074.00	2.32	46.30	9.00	0.03	561.48
	5109	27	32.50	344.20	126.00	1.28	16,636.00	1.22	12.93	4.73	0.05	624.72
	4496	15	8.33	257.80	36.30	0.86	11,866.00	0.56	17.28	2.43	0.06	795.31
	3906	3	5.87	224.10	14.00	0.85	8,482.00	1.88	71.83	4.49	0.27	2,718.59
	1192	0	41.88	146.30	1.00	0.86	2,039.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-6. AVERAGED POLARIS SNOWMOBILE EMISSIONS IN G/MI FOR GASOHOL TESTS

Polaris GHOL Averages	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6003	50	97.49	1,614.25	516.65	1.60	28,367.50	1.95	32.24	10.30	0.03	565.92
	5109	27	33.16	393.35	124.40	1.24	16,465.50	1.25	14.78	4.67	0.05	618.48
	4498	15	9.16	249.40	36.40	0.89	11,762.00	0.61	16.67	2.43	0.06	786.25
	3909	3	6.61	231.65	14.00	0.81	8,381.00	2.08	73.06	4.42	0.25	2,645.01
	1199	0	42.75	146.25	1.00	0.80	2,064.50	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

- Calculated Vehicle Speed (mph)
- Measured mass-based emissions (g/hr)
- Calculated emissions (g/mi)

TABLE D-7. ARCTIC CAT SNOWMOBILE EMISSIONS IN G/MI FOR AC-EEE-1

AC-EEE-1	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	5994	50.6	149.66	4,861.20	143.10	1.40	23,061.00	2.96	96.08	2.83	0.03	455.78
	5102	27.0	77.15	587.10	159.70	0.79	13,188.00	2.85	21.71	5.91	0.03	487.72
	4500	18.8	53.03	181.70	125.50	0.82	9,073.00	2.83	9.69	6.69	0.04	483.89
	3899	11.2	35.81	129.50	60.30	0.74	5,905.00	3.19	11.52	5.37	0.07	525.47
	1043	0	12.60	118.80	0.50	0.47	1,046.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-8. ARCTIC CAT SNOWMOBILE EMISSIONS IN G/MI FOR AC-EEE-2

AC-EEE-2	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6000	50.8	152.04	4,864.80	139.60	1.42	23,074.00	2.99	95.82	2.75	0.03	454.48
	5104	27.1	78.88	588.60	165.40	1.09	13,463.00	2.91	21.74	6.11	0.04	497.16
	4506	18.8	53.02	168.70	117.50	1.00	9,099.00	2.82	8.96	6.24	0.05	483.35
	3893	11.2	35.21	96.70	61.00	0.71	5,827.00	3.15	8.66	5.46	0.06	522.02
	1024	0	11.50	103.60	0.50	0.40	1,010.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-9. AVERAGED ARCTIC CAT SNOWMOBILE EMISSIONS IN G/MI FOR GASOLINE TESTS

Arctic Cat Engine EEE Averages	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	5997	51	150.85	4,863.00	141.35	1.41	23,067.50	2.98	95.95	2.79	0.03	455.13
	5103	27	78.02	587.85	162.55	0.94	13,325.50	2.88	21.72	6.01	0.03	492.44
	4503	19	53.03	175.20	121.50	0.91	9,086.00	2.82	9.33	6.47	0.05	483.62
	3896	11	35.51	113.10	60.65	0.73	5,866.00	3.17	10.09	5.42	0.06	523.74
	1033.5	0	12.05	111.20	0.50	0.44	1,028.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-10. ARCTIC CAT SNOWMOBILE EMISSIONS IN G/MI FOR AC-GHOL-1

AC-GHOL-1	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	5999	50.7	148.09	4,209.60	240.40	1.55	23,464.00	2.92	82.96	4.74	0.03	462.43
	5100	27.0	83.96	507.90	255.20	1.02	13,778.00	3.11	18.81	9.45	0.04	510.30
	4503	18.8	55.26	168.70	145.30	0.89	8,815.00	2.94	8.98	7.73	0.05	469.19
	3895	11.2	34.33	56.70	58.50	0.69	5,804.00	3.07	5.07	5.23	0.06	518.79
	1057	0	11.27	71.00	0.50	0.33	1,067.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-11. ARCTIC CAT SNOWMOBILE EMISSIONS IN G/MI FOR AC-GHOL-2

AC-GHOL-2	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6000	50.8	143.77	3,911.00	235.80	1.49	23,283.00	2.83	77.03	4.64	0.03	458.60
	5105	27.1	76.04	317.70	251.70	1.09	13,458.00	2.81	11.72	9.29	0.04	496.61
	4499	18.7	49.08	69.70	141.60	0.96	8,716.00	2.62	3.72	7.56	0.05	465.16
	3899	11.2	31.67	40.50	57.30	0.88	5,897.00	2.82	3.60	5.10	0.08	524.76
	1029	0	9.82	62.60	0.40	0.58	978.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

TABLE D-12. AVERAGED ARCTIC CAT SNOWMOBILE EMISSIONS IN G/MI FOR GASOHOL TESTS

Arctic Cat Engine GHOL Averages	Engine Speed (RPM)	Vehicle Speed (mph)	Emissions, g/hr					Emissions, g/mi				
			HC	CO	NOx	PM	CO ₂	HC	CO	NOx	PM	CO ₂
	6000	51	145.93	4,060.30	238.10	1.52	23,373.50	2.88	80.00	4.69	0.03	460.51
	5103	27	80.00	412.80	253.45	1.06	13,618.00	2.96	15.27	9.37	0.04	503.45
	4501	19	52.17	119.20	143.45	0.93	8,765.50	2.78	6.35	7.65	0.05	467.18
	3897	11	33.00	48.60	57.90	0.79	5,850.50	2.94	4.34	5.16	0.07	521.78
	1043	0	10.55	66.80	0.45	0.46	1,022.50	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

- Calculated Vehicle Speed (mph)
- Measured mass-based emissions (g/hr)
- Calculated emissions (g/mi)

APPENDIX E

ARCTIC CAT HYDROCARBON SPECIATION RESULTS

TABLE E-1. ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
METHANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHANE	2.05	0.51	1.28	0.32	0.78	0.19	0.54	0.14	0.12	0.03	0.07	0.02
ETHYLENE	13.73	100.09	6.02	43.86	4.10	29.86	2.64	19.27	0.62	4.51	0.37	2.71
PROPANE	0.11	0.05	0.07	0.03	0.10	0.05	0.07	0.04	0.03	0.02	0.01	0.00
PROPYLENE	12.10	113.78	5.44	51.15	3.45	32.41	2.09	19.65	0.39	3.69	0.32	3.02
ACETYLENE	5.35	2.68	2.66	1.13	1.59	0.80	1.28	0.64	0.52	0.26	0.15	0.07
PROPADIENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BUTANE	0.24	0.24	0.16	0.17	0.29	0.30	0.17	0.18	0.00	0.00	0.01	0.01
TRANS-2-BUTENE	0.88	8.73	0.53	5.24	0.21	2.04	0.22	2.20	0.03	0.30	0.03	0.27
1-BUTENE	0.19	1.72	0.00	0.00	0.36	3.19	0.00	0.00	0.00	0.00	0.01	0.07
2-METHYLPROPENE (ISOBUTYLENE)	8.97	47.64	4.03	21.40	2.42	12.87	1.49	7.91	0.27	1.43	0.23	1.25
2,2-DIMETHYLPROPANE (NEOPENTANE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PROPYNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,3-BUTADIENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLPROPANE (ISOBUTANE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-BUTYNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
METHANOL	0.35	0.19	0.29	0.16	0.53	0.29	0.63	0.35	0.00	0.00	0.03	0.02
CIS-2-BUTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-1-BUTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHANOL	0.02	0.02	0.06	0.07	0.03	0.04	0.08	0.11	0.07	0.00	0.00	0.00
2-METHYLPROPANE (ISOPENTANE)	4.20	5.80	2.68	3.70	1.99	2.75	1.28	1.77	0.00	0.00	0.15	0.21
2-BUTYNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-PENTENE	0.12	0.77	0.04	0.26	0.03	0.17	0.02	0.11	0.00	0.00	0.00	0.02
2-METHYL-1-BUTENE	0.39	1.93	0.27	1.30	0.18	0.90	0.10	0.50	0.02	0.10	0.01	0.07
PENTANE	1.57	1.64	0.97	1.01	0.70	0.73	0.42	0.43	0.16	0.17	0.06	0.06
UNIDENTIFIED C5 OLEFINS	0.04	0.36	0.00	0.00	0.00	0.00	0.02	0.16	0.00	0.00	0.00	0.01
2-METHYL-1,3-BUTADIENE	0.27	2.46	0.07	0.65	0.06	0.58	0.08	0.71	0.02	0.19	0.01	0.06
TRANS-2-PENTENE	0.09	0.77	0.06	0.52	0.04	0.40	0.03	0.23	0.00	0.00	0.00	0.03

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
3,3-DIMETHYL-1-BUTENE	0.03	0.13	0.04	0.18	0.04	0.16	0.05	0.23	0.00	0.00	0.00	0.01
CIS-2-PENTENE	0.05	0.46	0.04	0.32	0.02	0.20	0.04	0.34	0.04	0.35	0.00	0.02
2-METHYL-2-BUTENE	0.68	4.36	0.13	0.81	0.12	0.77	0.15	0.96	0.04	0.26	0.01	0.09
TERT-BUTANOL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYCLOPENTADIENE	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.00	0.00	0.00
2,2-DIMETHYLBUTANE	0.15	0.12	0.09	0.08	0.07	0.06	0.04	0.04	0.02	0.01	0.01	0.00
CYCLOPENTENE	0.06	0.48	0.04	0.31	0.03	0.24	0.02	0.14	0.00	0.00	0.00	0.02
4-METHYL-1-PENTENE	0.11	0.50	0.12	0.53	0.10	0.46	0.05	0.22	0.00	0.00	0.01	0.03
3-METHYL-1-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYCLOPENTANE	0.17	0.39	0.10	0.23	0.07	0.17	0.05	0.11	0.02	0.05	0.01	0.01
2,3-DIMETHYLBUTANE	0.54	0.57	0.34	0.36	0.23	0.25	0.16	0.18	0.09	0.09	0.02	0.02
MTBE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-METHYL-CIS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLPENTANE	0.69	1.05	0.38	0.59	0.28	0.42	0.20	0.30	0.10	0.15	0.02	0.04
4-METHYL-TRANS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYLPENTANE	0.38	0.58	0.20	0.31	0.15	0.23	0.11	0.16	0.06	0.09	0.01	0.02
2-METHYL-1-PENTENE	0.02	0.09	0.01	0.06	0.01	0.03	0.02	0.07	0.00	0.00	0.00	0.00
1-HEXENE	0.02	0.09	0.01	0.06	0.01	0.03	0.02	0.07	0.00	0.00	0.00	0.00
HEXANE	0.46	0.46	0.28	0.28	0.21	0.21	0.16	0.15	0.08	0.08	0.02	0.02
UNIDENTIFIED C6 OLEFINS	0.16	1.05	0.06	0.40	0.07	0.46	0.03	0.22	0.04	0.25	0.00	0.03
TRANS-3-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-3-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DI-ISOPROPYL ETHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-2-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-TRANS-2-PENTENE	0.03	0.18	0.02	0.13	0.01	0.09	0.01	0.07	0.00	0.00	0.00	0.01
2-METHYL-2-PENTENE	0.03	0.20	0.02	0.11	0.02	0.13	0.02	0.11	0.00	0.00	0.00	0.01
3-METHYLCYCLOPENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-2-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
ETBE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-CIS-2-PENTENE	0.03	0.22	0.01	0.09	0.01	0.08	0.01	0.07	0.00	0.00	0.00	0.01
2,2-DIMETHYLPENTANE, Note A	0.22	0.30	0.13	0.18	0.09	0.13	0.07	0.09	0.03	0.04	0.01	0.01
METHYLCYCLOPENTANE, Note A	0.21	0.60	0.13	0.36	0.09	0.25	0.06	0.18	0.03	0.08	0.01	0.02
2,4-DIMETHYLPENTANE	0.34	0.61	0.23	0.42	0.19	0.33	0.15	0.27	0.09	0.15	0.01	0.03
2,2,3-TRIMETHYLBUTANE	0.02	0.03	0.02	0.03	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
3,4-DIMETHYL-1-PENTENE	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYLCYCLOPENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BENZENE	4.69	1.97	1.94	0.82	1.32	0.56	0.99	0.42	0.38	0.16	0.13	0.05
3-METHYL-1-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,3-DIMETHYLPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.01
CYCLOHEXANE	0.35	0.44	0.16	0.20	0.10	0.13	0.00	0.00	0.05	0.06	0.01	0.01
2-METHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3-DIMETHYLPENTANE	0.38	0.58	0.22	0.33	0.19	0.28	0.14	0.21	0.09	0.14	0.01	0.02
1,1-DIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-AMYL METHYL ETHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYCLOHEXENE	0.03	0.18	0.02	0.11	0.01	0.08	0.01	0.08	0.00	0.00	0.00	0.01
3-METHYLHEXANE	0.11	0.15	0.07	0.10	0.06	0.08	0.04	0.06	0.03	0.04	0.00	0.01
CIS-1,3-DIMETHYLCYCLOPENTANE	0.03	0.08	0.02	0.05	0.01	0.03	0.01	0.03	0.00	0.00	0.00	0.00
3-ETHYLPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,2-DIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,3-DIMETHYLCYCLOPENTANE	0.03	0.08	0.01	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
1-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-TRIMETHYLPENTANE	2.72	2.53	2.30	2.14	1.91	1.78	1.46	1.36	0.85	0.79	0.14	0.13
2-METHYL-1-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-3-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEPTANE	0.16	0.13	0.09	0.07	0.07	0.06	0.07	0.06	0.04	0.03	0.01	0.00
CIS-3-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
UNIDENTIFIED C7	0.01	0.04	0.05	0.20	0.04	0.19	0.00	0.00	0.00	0.00	0.00	0.01
2-METHYL-2-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-TRANS-3-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-2-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-ETHYL-CIS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,4-TRIMETHYL-1-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3-DIMETHYL-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-2-HEPTENE	0.02	0.12	0.01	0.08	0.01	0.07	0.02	0.08	0.00	0.00	0.00	0.01
METHYLCYCLOHEXANE	0.29	0.54	0.18	0.33	0.14	0.25	0.10	0.18	0.06	0.12	0.01	0.02
CIS-1,2-DIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2-DIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,1,3-TRIMETHYLCYCLOPENTANE	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,4-TRIMETHYL-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,3-TRIMETHYLPENTANE	0.55	0.66	0.42	0.51	0.36	0.43	0.32	0.39	0.20	0.24	0.03	0.03
2,5-DIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-DIMETHYLHEXANE	0.38	0.57	0.35	0.52	0.29	0.44	0.19	0.29	0.10	0.15	0.02	0.03
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,3-DIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
2,3,4-TRIMETHYLPENTANE	0.54	0.86	0.75	1.20	0.69	1.11	0.55	0.88	0.34	0.55	0.05	0.08
2,3,3-TRIMETHYLPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOLUENE	23.23	63.41	12.95	35.34	9.68	26.41	7.32	19.99	3.52	9.60	0.81	2.20
2,3-DIMETHYLHEXANE	0.37	0.49	0.38	0.50	0.33	0.44	0.36	0.47	0.19	0.26	0.03	0.03
1,1,2-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,4-DIMETHYLHEXANE, Note B	0.03	0.04	0.03	0.04	0.03	0.03	0.02	0.03	0.01	0.02	0.00	0.00
4-METHYLHEPTANE	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.01	0.01	0.00	0.00

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
3-METHYLHEPTANE	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-1,3-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,4-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-ETHYLHEXANE	0.03	0.04	0.01	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00
2,2,5-TRIMETHYLHEXANE	0.68	0.66	0.58	0.56	0.51	0.49	0.39	0.38	0.21	0.20	0.04	0.03
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,1-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-1-ETHYL-CYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,4-TRIMETHYLHEXANE	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-TRIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,2-DIMETHYLCYCLOHEXANE	0.01	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-OCTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-4-OCTENE	0.02	0.13	0.02	0.08	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00
OCTANE	0.06	0.03	0.04	0.03	0.04	0.02	0.03	0.02	0.01	0.01	0.00	0.00
UNIDENTIFIED C8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-2-OCTENE	0.01	0.05	0.16	0.84	0.01	0.08	0.01	0.05	0.00	0.00	0.00	0.02
TRANS-1,3-DIMETHYLCYCLOHEXANE, Note C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-2-OCTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ISOPROPYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3,5-TRIMETHYLHEXANE	0.07	0.08	0.08	0.09	0.07	0.08	0.05	0.06	0.03	0.04	0.00	0.01
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-DIMETHYLHEPTANE	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00
4,4-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-1,2-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
ETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,6-DIMETHYLHEPTANE, Note D	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.01	0.02	0.00	0.00
1,1,3-TRIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,5-DIMETHYLHEPTANE, Note E	0.06	0.07	0.05	0.06	0.05	0.05	0.03	0.03	0.02	0.02	0.00	0.00
3,3-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,5-DIMETHYLHEPTANE, Note E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHYLBENZENE	2.05	5.53	1.23	3.33	0.81	2.18	0.56	1.51	0.14	0.38	0.07	0.19
2,3,4-TRIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
m- & p-XYLENE	3.69	27.21	1.45	10.70	0.74	5.48	0.52	3.81	0.17	1.28	0.09	0.63
4-METHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,4-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-ETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STYRENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o-XYLENE	1.42	9.19	0.65	4.18	0.37	2.40	0.25	1.61	0.10	0.64	0.04	0.24
1-NONENE	0.09	0.20	0.08	0.19	0.06	0.14	0.05	0.11	0.02	0.05	0.00	0.01
TRANS-3-NONENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-3-NONENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NONANE	0.07	0.04	0.07	0.04	0.06	0.03	0.04	0.02	0.02	0.01	0.00	0.00
TRANS-2-NONENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ISOPROPYLBENZENE (CUMENE)	0.15	0.35	0.11	0.25	0.08	0.18	0.06	0.12	0.02	0.05	0.01	0.01
2,2-DIMETHYLOCTANE	0.09	0.09	0.06	0.06	0.04	0.04	0.02	0.03	0.00	0.00	0.00	0.00
2,4-DIMETHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-PROPYLBENZENE	0.90	1.91	0.67	1.41	0.44	0.94	0.29	0.62	0.12	0.25	0.04	0.08
1-METHYL-3-ETHYLBENZENE	4.79	34.47	2.90	20.89	1.73	12.48	1.17	8.39	0.48	3.43	0.16	1.13
1-METHYL-4-ETHYLBENZENE	1.93	13.93	1.19	8.60	0.74	5.33	0.47	3.37	0.19	1.40	0.06	0.47

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
1,3,5-TRIMETHYLBENZENE	2.76	27.97	1.46	14.78	0.84	8.50	0.56	5.66	0.24	2.39	0.08	0.82
1-METHYL-2-ETHYLBENZENE	1.94	13.93	1.18	8.48	0.68	4.88	0.56	4.02	0.26	1.90	0.07	0.47
1,2,4-TRIMETHYLBENZENE	10.72	94.63	5.21	46.05	2.78	24.52	1.73	15.27	0.06	0.53	0.28	2.51
TERT-BUTYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-DECENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DECANE, Note F	0.04	0.02	0.02	0.01	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00
ISOBUTYLBENZENE, Note F	0.03	0.06	0.02	0.04	0.03	0.05	0.01	0.02	0.00	0.00	0.00	0.00
1,3-DIMETHYL-5-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
METHYLPROPYLBENZENE (sec butylbenzene)	0.04	0.08	0.04	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-3-ISOPROPYLBENZENE	1.58	9.22	0.83	4.86	0.00	0.00	0.22	1.28	0.00	0.00	0.03	0.20
1,2,3-TRIMETHYLBENZENE	0.02	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-4-ISOPROPYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INDAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-2-ISOPROPYLBENZENE	0.27	1.59	0.08	0.44	0.11	0.61	0.00	0.00	0.00	0.00	0.01	0.30
1,3-DIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,4-DIETHYLBENZENE	0.25	1.64	0.14	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
1-METHYL-3-N-PROPYLBENZENE	0.73	4.70	0.26	1.66	0.00	0.00	0.06	0.35	0.03	0.22	0.00	0.08
1-METHYL-4-N-PROPYLBENZENE, Note G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
1,2 DIETHYLBENZENE	0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.00	0.00
1-METHYL-2-N-PROPYLBENZENE	0.01	0.08	0.10	0.65	0.00	0.00	0.08	0.54	0.00	0.00	0.00	0.03
1,4-DIMETHYL-2-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,3-DIMETHYL-4-ETHYLBENZENE	0.45	4.04	0.31	2.81	0.04	0.34	0.05	0.43	0.00	0.00	0.01	0.11
1,2-DIMETHYL-4-ETHYLBENZENE	0.15	1.37	0.19	1.69	0.02	0.18	0.03	0.23	0.02	0.17	0.01	0.05
1,3-DIMETHYL-2-ETHYLBENZENE	0.09	0.84	0.24	2.16	0.09	0.81	0.02	0.19	0.00	0.00	0.01	0.07
UNDECANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2-DIMETHYL-3-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,4,5-TETRAMETHYLBENZENE	0.01	0.08	0.00	0.00	0.03	0.25	0.00	0.00	0.00	0.00	0.00	0.01
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
3,4 DIMETHYLCUMENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,5-TETRAMETHYLBENZENE	0.11	0.97	0.04	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
TERT-1-BUT-2-METHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,4-TETRAMETHYLBENZENE	0.02	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N-PENT-BENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-1-BUT-3,5-DIMETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-1-BUTYL-4-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NAPHTHALENE	0.14	0.16	0.04	0.04	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
DODECANE	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1,3,5-TRIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,4-TRIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEXYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNIDENTIFIED C9-C12+	2.00	7.60	1.17	4.48	1.40	5.32	0.51	1.93	0.40	1.52	0.08	0.30
FORMALDEHYDE	2.31	16.53	2.50	17.90	2.09	14.95	1.34	9.55	0.14	0.97	0.14	0.98
ACETALDEHYDE	0.43	2.37	0.40	2.20	0.37	2.06	0.25	1.37	0.00	0.00	0.02	0.13
ACROLEIN	0.10	0.67	0.09	0.62	0.08	0.54	0.03	0.22	0.00	0.00	0.00	0.03
ACETONE	0.09	0.05	0.10	0.05	0.09	0.05	0.04	0.02	0.00	0.00	0.01	0.00
PROPIONALDEHYDE	0.03	0.20	0.04	0.26	0.04	0.29	0.03	0.21	0.00	0.00	0.00	0.02
CROTONALDEHYDE	0.06	0.32	0.09	0.49	0.10	0.57	0.08	0.43	0.00	0.01	0.01	0.03
ISOBUTYRALDEHYDE, Note H	0.08	0.43	0.03	0.16	0.03	0.14	0.05	0.29	0.00	0.00	0.00	0.02
METHYL ETHYL KETONE, Note H	0.08	0.10	0.03	0.04	0.03	0.03	0.05	0.06	0.00	0.00	0.00	0.00
BENZALDEHYDE	0.88	-0.48	0.85	-0.47	0.68	-0.37	0.39	-0.21	0.05	-0.03	0.05	-0.03
ISOVALERALDEHYDE	0.12	0.54	0.03	0.12	0.02	0.07	0.00	0.00	0.00	0.00	0.00	0.01

TABLE E-1 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-EEE-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
VALERALDEHYDE	0.06	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O-TOLUALDEHYDE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/P-TOLUALDEHYDE	0.55	-0.30	0.49	-0.27	0.36	-2.00	0.05	-0.03	0.01	-0.01	0.02	-0.01
HEXANALDEHYDE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DIMETHYLBENZALDEHYDE	0.05	-0.03	0.21	-0.12	0.19	-0.10	0.10	-0.05	0.01	-0.01	0.01	-0.01
SUMMED SPECIATED VALUES	131.50	658.96	72.25	341.33	49.95	218.31	34.46	145.04	11.51	40.03	4.27	19.72
<p>A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds. B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately. C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately. D - Propylcyclopentane co-elutes with reported compound. Not reported separately. E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds. F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds. G - n-Butylbenzene co-elutes with reported compound. Not reported separately. H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.</p>												

TABLE E-2. ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
METHANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHANE	2.36	0.59	1.61	0.40	0.78	0.20	0.45	0.11	0.13	0.03	0.08	0.02
ETHYLENE	15.47	112.81	8.31	60.60	0.84	6.15	0.14	1.04	0.60	4.36	0.33	2.42
PROPANE	0.11	0.05	0.02	0.01	0.24	0.11	0.00	0.00	0.00	0.00	0.01	0.00
PROPYLENE	13.02	122.37	7.10	66.71	7.23	67.92	2.28	21.43	0.40	3.76	0.46	4.29
ACETYLENE	5.48	2.74	2.88	1.44	2.98	1.49	1.26	0.63	0.44	0.22	0.20	0.10
PROPADIENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BUTANE	0.84	0.85	0.58	0.59	0.58	0.59	0.20	0.21	0.00	0.00	0.04	0.04
TRANS-2-BUTENE	0.81	8.01	0.50	5.00	0.53	5.25	0.15	1.53	0.00	0.00	0.03	0.31
1-BUTENE	1.02	9.05	0.71	6.33	0.76	6.77	0.26	2.33	0.04	0.34	0.04	0.40
2-METHYLPROPENE (ISOBUTYLENE)	9.29	49.33	5.15	27.36	5.21	27.67	1.55	8.21	0.31	1.63	0.33	1.73
2,2-DIMETHYLPROPANE (NEOPENTANE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PROPYNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,3-BUTADIENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLPROPANE (ISOBUTANE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-BUTYNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
METHANOL	0.30	0.17	0.65	0.36	0.49	0.27	0.49	0.27	0.00	0.00	0.04	0.02
CIS-2-BUTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-1-BUTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHANOL	4.07	5.46	2.07	2.77	1.91	2.56	1.21	1.62	0.11	0.15	0.14	0.19
2-METHYLPROPANE (ISOPENTANE)	5.12	7.06	3.79	5.23	4.49	6.19	1.42	1.96	0.45	0.63	0.24	0.34
2-BUTYNE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-PENTENE	0.06	0.40	0.06	0.39	0.06	0.40	0.03	0.20	0.00	0.00	0.00	0.02
2-METHYL-1-BUTENE	0.40	1.97	0.29	1.44	0.18	0.86	0.10	0.47	0.00	0.00	0.02	0.07
PENTANE	1.79	1.86	1.10	1.14	0.88	0.92	0.40	0.42	0.01	0.01	0.06	0.07
UNIDENTIFIED C5 OLEFINS	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYL-1,3-BUTADIENE	0.40	3.66	0.16	1.48	0.10	0.91	0.09	0.86	0.12	1.05	0.01	0.11
TRANS-2-PENTENE	0.09	0.79	0.06	0.55	0.04	0.36	0.02	0.19	0.01	0.12	0.00	0.03

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
3,3-DIMETHYL-1-BUTENE	0.04	0.16	0.05	0.21	0.03	0.15	0.02	0.07	0.00	0.00	0.00	0.01
CIS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYL-2-BUTENE	0.67	4.29	0.37	2.37	0.01	0.07	0.03	0.19	0.00	0.00	0.01	0.09
TERT-BUTANOL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYCLOPENTADIENE	0.00	0.00	0.01	0.10	0.00	0.00	0.01	0.10	0.00	0.00	0.00	0.00
2,2-DIMETHYLBUTANE	0.16	0.13	0.10	0.08	0.08	0.07	0.04	0.03	0.01	0.01	0.01	0.01
CYCLOPENTENE	0.07	0.50	0.05	0.35	0.03	0.25	0.02	0.13	0.00	0.00	0.00	0.02
4-METHYL-1-PENTENE	0.07	0.29	0.16	0.70	0.15	0.64	0.06	0.28	0.00	0.00	0.01	0.04
3-METHYL-1-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYCLOPENTANE	0.18	0.43	0.11	0.25	0.08	0.19	0.04	0.10	0.02	0.04	0.01	0.02
2,3-DIMETHYLBUTANE	0.53	0.57	0.37	0.39	0.26	0.28	0.15	0.16	0.07	0.08	0.02	0.02
MTBE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-METHYL-CIS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLPENTANE	0.70	1.07	0.42	0.64	0.30	0.46	0.17	0.27	0.10	0.15	0.03	0.04
4-METHYL-TRANS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYLPENTANE	0.38	0.58	0.22	0.34	0.17	0.25	0.10	0.15	0.05	0.08	0.01	0.02
2-METHYL-1-PENTENE	0.03	0.11	0.02	0.07	0.01	0.02	0.01	0.06	0.00	0.00	0.00	0.00
1-HEXENE	0.03	0.11	0.02	0.07	0.01	0.02	0.01	0.06	0.00	0.00	0.00	0.00
HEXANE	0.46	0.45	0.27	0.27	0.22	0.21	0.13	0.13	0.06	0.05	0.02	0.02
UNIDENTIFIED C6 OLEFINS	0.18	1.22	0.09	0.58	0.08	0.56	0.03	0.20	0.04	0.27	0.01	0.04
TRANS-3-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-3-HEXENE	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DI-ISOPROPYL ETHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-2-HEXENE	0.03	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-TRANS-2-PENTENE	0.03	0.21	0.02	0.14	0.01	0.09	0.01	0.07	0.00	0.00	0.00	0.01
2-METHYL-2-PENTENE	0.00	0.00	0.03	0.18	0.02	0.16	0.02	0.11	0.00	0.00	0.00	0.01
3-METHYLCYCLOPENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-2-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
ETBE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-CIS-2-PENTENE	0.03	0.19	0.02	0.12	0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.01
2,2-DIMETHYLPENTANE, Note A	0.22	0.31	0.14	0.19	0.09	0.13	0.06	0.08	0.02	0.03	0.01	0.01
METHYLCYCLOPENTANE, NoteA	0.21	0.60	0.13	0.37	0.09	0.26	0.06	0.16	0.02	0.06	0.01	0.02
2,4-DIMETHYLPENTANE	0.34	0.61	0.23	0.41	0.19	0.33	0.12	0.21	0.07	0.13	0.01	0.03
2,2,3-TRIMETHYLBUTANE	0.03	0.04	0.02	0.03	0.02	0.03	0.01	0.02	0.00	0.00	0.00	0.00
3,4-DIMETHYL-1-PENTENE	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYLCYCLOPENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BENZENE	4.19	1.76	1.88	0.79	1.04	0.44	0.78	0.33	0.25	0.10	0.12	0.05
3-METHYL-1-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,3-DIMETHYLPENTANE	0.02	0.02	0.04	0.03	0.03	0.02	0.02	0.02	0.06	0.04	0.00	0.00
CYCLOHEXANE	0.31	0.40	0.18	0.23	0.12	0.16	0.08	0.10	0.00	0.00	0.01	0.01
2-METHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3-DIMETHYLPENTANE	0.36	0.54	0.21	0.31	0.19	0.29	0.13	0.19	0.08	0.12	0.01	0.02
1,1-DIMETHYLCYCLOPENTANE	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-AMYL METHYL ETHER	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYCLOHEXENE	0.03	0.15	0.02	0.13	0.02	0.10	0.01	0.08	0.00	0.00	0.00	0.01
3-METHYLHEXANE	0.09	0.13	0.06	0.09	0.05	0.07	0.03	0.05	0.02	0.03	0.00	0.01
CIS-1,3-DIMETHYLCYCLOPENTANE	0.03	0.08	0.02	0.04	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00
3-ETHYLPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,2-DIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,3-DIMETHYLCYCLOPENTANE	0.02	0.05	0.01	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
1-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-TRIMETHYLPENTANE	2.75	2.56	2.31	2.15	1.97	1.84	1.30	1.21	0.74	0.69	0.14	0.13
2-METHYL-1-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-3-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEPTANE	0.26	0.21	0.08	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.01	0.01
CIS-3-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
UNIDENTIFIED C7	0.03	0.12	0.00	0.00	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYL-2-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYL-TRANS-3-HEXENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-2-HEPTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-ETHYL-CIS-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,4-TRIMETHYL-1-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3-DIMETHYL-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-2-HEPTENE	0.00	0.00	0.03	0.14	0.02	0.09	0.01	0.08	0.00	0.00	0.00	0.01
METHYLCYCLOHEXANE	0.29	0.54	0.18	0.33	0.13	0.24	0.08	0.15	0.05	0.10	0.01	0.02
CIS-1,2-DIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2-DIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,1,3-TRIMETHYLCYCLOPENTANE	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,4-TRIMETHYL-2-PENTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,3-TRIMETHYLPENTANE	0.51	0.61	0.41	0.49	0.34	0.41	0.28	0.33	0.18	0.21	0.03	0.03
2,5-DIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-DIMETHYLHEXANE	0.37	0.55	0.34	0.52	0.31	0.47	0.17	0.25	0.08	0.13	0.02	0.03
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.01	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
3,3-DIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3,4-TRIMETHYLPENTANE	0.62	0.99	0.76	1.21	0.73	1.17	0.49	0.78	0.29	0.47	0.05	0.08
2,3,3-TRIMETHYLPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOLUENE	20.90	57.04	11.98	32.71	8.24	22.49	5.16	14.09	1.89	5.16	0.72	1.97
2,3-DIMETHYLHEXANE	0.35	0.46	0.41	0.54	0.29	0.38	0.18	0.23	0.17	0.22	0.02	0.03
1,1,2-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,4-DIMETHYLHEXANE, Note	0.03	0.05	0.03	0.04	0.03	0.04	0.02	0.02	0.01	0.01	0.00	0.00
4-METHYLHEPTANE	0.00	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
3-METHYLHEPTANE	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-1,3-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,4-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-ETHYLHEXANE	0.05	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
2,2,5-TRIMETHYLHEXANE	0.69	0.67	0.59	0.57	0.49	0.48	0.34	0.33	0.18	0.18	0.04	0.04
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,1-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-1-ETHYL-CYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,4-TRIMETHYLHEXANE	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2,4-TRIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-1,2-DIMETHYLCYCLOHEXANE	0.02	0.04	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-OCTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-4-OCTENE	0.02	0.10	0.01	0.06	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00
OCTANE	0.06	0.03	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00
UNIDENTIFIED C8	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TRANS-2-OCTENE	0.01	0.06	0.02	0.10	0.02	0.09	0.01	0.06	0.00	0.00	0.00	0.01
TRANS-1,3-DIMETHYLCYCLOHEXANE, NoteC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-2-OCTENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ISOPROPYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,2-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3,5-TRIMETHYLHEXANE	0.08	0.09	0.08	0.09	0.07	0.08	0.05	0.05	0.03	0.03	0.00	0.00
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-DIMETHYLHEPTANE	0.02	0.03	0.02	0.02	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00
4,4-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-1,2-DIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
ETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,6-DIMETHYLHEPTANE, NoteD	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00
1,1,3-TRIMETHYLCYCLOHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,5-DIMETHYLHEPTANE, Note E	0.06	0.07	0.06	0.07	0.05	0.05	0.03	0.03	0.02	0.02	0.00	0.00
3,3-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,5-DIMETHYLHEPTANE, Note E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ETHYLBENZENE	1.91	5.15	1.20	3.24	0.65	1.75	0.43	1.16	0.11	0.29	0.06	0.11
2,3,4-TRIMETHYLHEXANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,3-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
m- & p-XYLENE	3.00	22.16	1.28	9.43	0.53	3.92	0.33	2.42	0.11	0.78	0.07	0.53
4-METHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3,4-DIMETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-ETHYLHEPTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-METHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STYRENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o-XYLENE	1.18	7.61	0.58	3.75	0.40	2.62	0.17	1.10	0.07	0.44	0.03	0.22
1-NONENE	0.10	0.21	0.11	0.24	0.06	0.13	0.04	0.08	0.02	0.05	0.01	0.01
TRANS-3-NONENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIS-3-NONENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NONANE	0.08	0.04	0.07	0.04	0.05	0.03	0.03	0.02	0.02	0.01	0.00	0.00
TRANS-2-NONENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.00
ISOPROPYLBENZENE (CUMENE)	0.14	0.31	0.12	0.26	0.08	0.18	0.05	0.11	0.00	0.00	0.01	0.01
2,2-DIMETHYLOCTANE	0.07	0.07	0.05	0.05	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00
2,4-DIMETHYLOCTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
n-PROPYLBENZENE	0.89	1.89	0.67	1.41	0.44	0.93	0.25	0.53	0.10	0.22	0.04	0.08
1-METHYL-3-ETHYLBENZENE	4.45	32.04	2.86	20.58	1.62	11.66	0.98	7.09	0.41	2.98	0.15	1.11
1-METHYL-4-ETHYLBENZENE	1.98	14.29	1.20	8.61	0.73	5.28	0.40	2.91	0.15	1.11	0.07	0.48

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
1,3,5-TRIMETHYLBENZENE	2.54	25.75	1.44	14.53	0.79	7.97	0.47	4.71	0.21	2.15	0.08	0.80
1-METHYL-2-ETHYLBENZENE	1.83	13.19	1.16	8.39	0.66	4.78	0.38	2.77	0.18	1.32	0.06	0.45
1,2,4-TRIMETHYLBENZENE	9.04	79.83	5.22	46.07	2.61	23.00	1.33	11.78	0.04	0.40	0.27	2.38
TERT-BUTYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-DECENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DECANE, Note F	0.04	0.02	0.02	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
ISOBUTYLBENZENE, Note F	0.04	0.07	0.02	0.04	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00
1,3,-DIMETHYL-5-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
METHYLPROPYLBENZENE (sec butylbenzene)	0.05	0.09	0.04	0.08	0.00	0.00	0.02	0.05	0.00	0.00	0.00	0.00
1-METHYL-3-ISOPROPYLBENZENE	1.40	8.16	0.80	4.68	0.46	2.68	0.08	0.48	0.00	0.00	0.04	0.23
1,2,3-TRIMETHYLBENZENE	0.02	0.16	0.01	0.08	0.00	0.00	0.05	0.41	0.00	0.00	0.00	0.01
1-METHYL-4-ISOPROPYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INDAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-2-ISOPROPYLBENZENE	0.16	0.95	0.22	1.26	0.09	0.55	0.05	0.31	0.03	0.19	0.01	0.05
1,3-DIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,4-DIETHYLBENZENE	0.24	1.53	0.13	0.82	0.02	0.15	0.03	0.18	0.00	0.00	0.01	0.04
1-METHYL-3-N-PROPYLBENZENE	0.62	4.00	0.29	1.90	0.03	0.21	0.01	0.06	0.04	0.25	0.01	0.08
1-METHYL-4-N-PROPYLBENZENE, Note G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2 DIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-METHYL-2-N-PROPYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,4-DIMETHYL-2-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,3-DIMETHYL-4-ETHYLBENZENE	0.31	2.84	0.32	2.93	0.13	1.17	0.07	0.68	0.02	0.15	0.01	0.12
1,2-DIMETHYL-4-ETHYLBENZENE	0.10	0.93	0.04	0.38	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.02
1,3-DIMETHYL-2-ETHYLBENZENE	0.08	0.77	0.05	0.41	0.04	0.37	0.02	0.23	0.01	0.07	0.00	0.03
UNDECANE	0.00	0.00	0.03	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
1,2-DIMETHYL-3-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,4,5-TETRAMETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
3,4 DIMETHYLCUMENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,5-TETRAMETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-1-BUT-2-METHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,4-TETRAMETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N-PENT-BENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-1-BUT-3,5-DIMETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TERT-1-BUTYL-4-ETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NAPHTHALENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DODECANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,3,5-TRIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,2,4-TRIETHYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HEXYLBENZENE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UNIDENTIFIED C9-C12+	1.82	6.94	1.16	4.42	1.06	4.02	0.80	3.04	0.87	3.32	0.08	0.31
FORMALDEHYDE	2.99	21.35	2.65	18.92	2.22	15.84	0.19	1.38	0.04	0.26	0.13	0.92
ACETALDEHYDE	1.37	7.55	0.94	5.18	0.60	3.31	0.11	0.60	0.02	0.13	0.05	0.25
ACROLEIN	0.25	1.71	0.25	1.71	0.16	1.05	0.02	0.16	0.00	0.00	0.01	0.07
ACETONE	0.13	0.07	0.16	0.09	0.04	0.02	0.00	0.00	0.00	0.00	0.01	0.00
PROPIONALDEHYDE	0.17	1.10	0.19	1.26	0.10	0.63	0.00	0.00	0.00	0.00	0.01	0.05
CROTONALDEHYDE	0.08	0.46	0.13	0.72	0.10	0.52	0.00	0.00	0.00	0.00	0.01	0.03
ISOBUTYRALDEHYDE, Note H	0.02	0.13	0.02	0.13	0.02	0.13	0.00	0.00	0.01	0.06	0.00	0.01
METHYL ETHYL KETONE, Note H	0.02	0.03	0.02	0.03	0.02	0.03	0.00	0.00	0.01	0.01	0.00	0.00
BENZALDEHYDE	0.88	-0.48	0.77	-0.42	0.47	-0.26	0.06	-0.03	0.00	0.00	0.03	-0.02
ISOVALERALDEHYDE	0.04	0.16	0.04	0.16	0.02	0.11	0.00	0.00	0.00	0.00	0.00	0.00

TABLE E-2 (CONT'D). ARCTIC CAT SPECIATION RESULTS (AC-GHOL-1)

COMPOUND	MODE 1		MODE 2		MODE 3		MODE 4		MODE 5		Weighted Results	
	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	g/hr	Ozone, g/hr	Composite, g/hp-hr	Ozone, g/hp-hr
VALERALDEHYDE	0.02	0.11	0.02	0.11	0.02	0.11	0.00	0.00	0.00	0.00	0.00	0.01
O-TOLUALDEHYDE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M/P-TOLUALDEHYDE	0.44	-0.24	0.35	-0.19	0.05	-0.03	0.04	-0.02	0.00	0.00	0.01	-0.01
HEXANALDEHYDE	0.00	0.00	0.00	0.00	0.04	0.14	0.00	0.00	0.00	0.00	0.00	0.00
DIMETHYLBENZALDEHYDE	0.26	-0.15	0.23	-0.13	0.13	-0.07	0.01	-0.01	0.00	0.00	0.01	-0.01
SUMMED SPECIATED VALUES	136.01	667.67	82.59	391.74	58.08	255.31	26.93	104.77	9.68	35.00	4.70	21.53
<p>A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.</p> <p>B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.</p> <p>C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.</p> <p>D - Propylcyclopentane co-elutes with reported compound. Not reported separately.</p> <p>E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.</p> <p>F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.</p> <p>G - n-Butylbenzene co-elutes with reported compound. Not reported separately.</p> <p>H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.</p>												